Reducing Toxic Exposure from Fish Consumption in Women of Childbearing Age and Urban Anglers: Results of a Two-Year Diary Study

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*This is a living document. A series of manuscripts that will eventually be included in this report are under review by peer-reviewed journals. As these manuscripts are published they will be added to this document and the version number updated. When all manuscripts have been added, the cover will read “Final Version.”

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INTRODUCTION AND SUMMARY

The ultimate goal of this project was to find ways to reduce exposure to toxic substances from Great Lakes fish consumption among women of child-bearing age (WCBA) and urban anglers. The Great Lakes Restoration Initiative Action Plan II identifies these two groups as being at particular risk from exposure to toxic substances from fish consumption. While consuming fish provides important health benefits to women, developing fetuses and children, consuming too much contaminated fish can lead to a variety of problems in children, including birth defects and learning difficulties. In addition, urban waters in industrialized areas may be polluted, and some types of fish in those waters accumulate high levels of industrial contaminants. Urban anglers are considered more likely than other anglers to fish at urban sites and, if they eat the fish they catch, more likely to be exposed to the contaminants in these fish. Consequently, state health departments in the Great Lakes states have made ongoing, long-term efforts to encourage urban anglers and WCBA to continue to eat fish, but within recommended limits.

Part of this effort has included research on how best to communicate messages about risks and benefits of fish consumption to prompt desired behavioral responses. The research has been fruitful in identifying the types of messages and materials that WCBA and urban anglers think would be most likely to encourage them to eat fish within recommended limits. These messages and materials had not yet been tested, however, to determine if they actually influence behavior as intended. This type of testing is important because the process through which communication leads to behavior change is complex; it involves a person receiving messages, correctly understanding them, considering them credible, incorporating relevant information, intending to follow their recommendations, and engaging consistently in the particular behavior (in this case, healthy fish consumption). A message or material may be perceived very positively by representatives of a target audience, but not actually influence behavior as expected. Consequently, we designed a study that would evaluate the impacts of communication of fish consumption guidelines and messages on healthy fish consumption behavior.

To assess behavioral impacts, we conducted a randomized experiment in which we determined the degree to which fish consumption guidelines and materials (developed on the basis of practitioners' insights and past research) reduced the consumption of fish high in toxic substances by WCBA and urban anglers, while still encouraging consumption of fish for the health benefits they provide. We selected a sample of WCBA and urban anglers from the Great Lakes region, gathered detailed information about their fish consumption patterns (including the degree to which these patterns conform to their states' health departments' recommendations), distributed fish consumption messages and guidelines to a randomly selected subset of this sample as an intervention, and gathered detailed information about how these messages and guidelines influenced fish consumption patterns. We hope these results will be used by the Great Lakes states to further enhance their programs to communicate the risks and benefits of fish consumption.

We have organized this report into six sections following the Introduction and Summary. Each section describes an important component of the study. The sections are written as peer-reviewed journal articles, and will appear in this living document as they are published and we

receive permission from the publisher. Currently, one manuscript appears in its entirety (Section 2) and the others list the journals to which the manuscripts are being submitted. The sections are:

- Section 1: Using a Web-based Diary Method to Estimate Risks and Benefits from Fish Consumption
- Section 2: Fish Consumption among Women Anglers of Childbearing Age in the Great Lakes Region
- Section 3: Are Women Anglers of Childbearing Age in the Great Lakes Region Following Fish Consumption Guidelines?
- Section 4: Effects of a Personal Narrative in Messages Designed to Promote Healthy Fish Consumption among Women of Childbearing Age
- Section 5: Urban Anglers' Adherence to Fish Consumption Advisories in the Great Lakes Region
- Section 6: Effects of an Advisory Brochure on Fish Consumption of Urban Anglers in the Great Lakes Region

Each section includes footnotes that provide the reader with related information and sometimes reference appendices with more detailed analyses that were beyond the scope of the journal manuscripts. (This information is primarily intended to answer questions raised at the Great Lakes Consortium for Fish Consumption Advisories meeting held in Chicago in March, 2016.) We provide a summary of each section below. We follow these six summaries with a description of the outputs and outcomes of this project.

Summary of Section 1: Using a Web-based Diary Method to Estimate Risks and Benefits from Fish Consumption

Objective: Accurate estimates of the amount and type of fish people eat are necessary to determine the health benefits and risks people face from consuming fish and to assess compliance with fish consumption guidelines. We examine the strengths and weaknesses of using a diary method for collecting such fish consumption information.
Design: We developed a web-based (and mobile phone-enabled) diary methodology to collect detailed fish consumption information for two 16-week periods in the summers of 2014 and 2015.
Participants: We recruited study participants from two populations of licensed anglers living in the Great Lakes region – women of childbearing age (WCBA) and urban residents.
Results: At the end of the first year of data collection, 81% of WCBA and 79% of urban anglers provided at least some fish consumption information. In total, 58% of WCBA and 52% of urban anglers provided complete data across both data collection periods. Among those who provided information at the beginning of Year 2, 97% of both audiences provided information throughout the entire 16-week period. Those who participated throughout the two-year period were older on average (1.9-2.5 years) than other members of our original samples.
Conclusions: Using diaries with web and smartphone technology, combined with incentives and persistent communication, has great potential for assessing fish consumption for situations where the potential risks associated with fish consumption are substantial and the cost can be justified.

The primary limitation of this method is the large cost associated with recruitment and incentive payments.

Summary of Section 2: Fish Consumption among Women Anglers of Childbearing Age in the Great Lakes Region

Objective: Fish consumption advisories are issued by the federal government for women of childbearing age (WCBA). These advisories make recommendations about the amount and types of fish that should be consumed to provide the greatest health benefits to women and their children while avoiding risks from chemical contaminants. Our objective was to describe the fish consumption habits of WCBA anglers and compare their consumption levels with the USDA and (current and proposed) EPA/FDA recommendations.
Design: We used diary methods to study fish consumption patterns for a 4-month period during the summer of 2014.
Participants: We obtained consumption data from 1,395 WCBA in the Great Lakes coastal region who purchased fishing licenses, a group which has significant opportunity to eat larger quantities of fish.
Results: Very few members of this group reported exceeding the federal recommendations for total fish consumption (between 3% and 5% depending on assumptions about portion sizes), consumption of canned "white" tuna (0%), or consumption of "do not eat" purchased fish species (4%). WCBA did report eating more fish on average than recent national study estimates, but they did not report consuming as much fish as is recommended to obtain the greatest health benefits of fish consumption. Only 10–12% of study participants reported eating within the recommended range of 8–12oz. of fish per week, with 84–87% eating less than the recommended amount.
Conclusions: Additional efforts are likely needed to encourage WCBA to eat more low-risk fish, even among this group of higher-than-average fish consumers.

Summary of Section 3: Are Women Anglers of Childbearing Age in the Great Lakes Region Following Fish Consumption Guidelines?

Objective: States in the Great Lakes region of the United States issue fish consumption guidelines for women of childbearing age (WCBA) to help them minimize the health risks to themselves and their potential offspring from eating fish contaminated with chemicals. Our objective was to examine the fish consumption patterns of WCBA and determine if WCBA were aware of the guidelines and following them.
Design: We used diary methods to study fish consumption patterns for a 4-month period during the summer of 2014, and a survey to assess awareness of the guidelines.
Participants: We obtained consumption data from 1,395 WCBA in the Great Lakes coastal region who purchased fishing licenses.
Results: We found that two-thirds of WCBA reported at least minimal awareness of the fish consumption guidelines issued by the states and federal government, and those that reported awareness were more likely to hold beliefs consistent with the messages emphasized in the guidelines. WCBA reported eating less than one meal/week of fish with most of this fish purchased at a store or restaurant. On average, they consumed just 2.4 sport-caught fish meals over the 16-week study period. The average portion size for sport-caught fish meals eaten by

WCBA was similar to that assumed by states when determining the guidelines. One-quarter of WCBA in our study exceeded the state guidelines for sport-caught and purchased fish, with rates as high as 41% exceeding these guidelines in Michigan and Minnesota.
Conclusions: Additional outreach efforts may be needed to increase compliance with fish consumption guidelines, particularly among subpopulations that exceed the guidelines more frequently.

Summary of Section 4: Effects of a Personal Narrative in Messages Designed to Promote Healthy Fish Consumption among Women of Childbearing Age

Objective: To test the impact of brochures designed to promote healthy fish consumption among licensed female anglers of childbearing age.
Design: We conducted a randomized, two-wave longitudinal experiment between May 18th, 2014 and September 5th, 2015. Participants reported their fish consumption in summer 2014 via an online diary. We then randomly assigned women to either be sent one of four brochures in spring 2015 using a two (including a short personal narrative or not) by two (using certain or uncertain language) factorial design, or to a fifth, no-exposure control arm. All participants completed a fish consumption diary again in summer 2015. We used ordinary least squares regression to test the effect of the brochures on fish consumption.
Participants: 1,135 women of childbearing age (18 to 48 years of age at baseline) drawn from a sample of licensed anglers who completed an online diary of their fish consumption in both years of the study.
Results: There were no overall effects of randomized condition on fish consumption, driven by low levels of confirmed exposure to the brochure among treatment groups. Among those confirmed to have seen it, however, exposure to brochure versions that included a short personal narrative helped to move women whose levels of fish consumption at baseline were furthest from federally recommended levels closer to these guidelines.
Conclusions: Narratives hold promise as a strategy to effectively convey information about the risks and benefits of fish consumption among women of childbearing age, but more research is needed to identify strategies to maximize exposure to these messages.

Summary of Section 5: Urban Anglers' Adherence to Fish Consumption Advisories in the Great Lakes Region

Objective: Previous research suggests that urban anglers are a group at high risk of being exposed to contaminants from fish consumption. Past studies of urban anglers' fish consumption, however, have had significant limitations making it difficult to generalize their findings broadly and to assess the degree to which urban anglers are complying with advisory recommendations. In three cities in the Great Lakes region, we assessed how much fish urban anglers consumed, whether they complied with fish consumption advisories, and how fish consumption and advisory compliance varied for different demographic groups and in different locations.
Design: We used a diary method to collect detailed information on fish consumption for a 4-month period during the summer of 2014.
Participants: We collected fish consumption data from a representative sample of 1,363 licensed anglers in the three counties containing Rochester, NY, Erie, PA, and Kalamazoo, MI.

Results: We estimated a mean of 1.12 meals/week of fish and 25.1-26.8 grams/day of fish, and the amount of fish consumed varied by no more than 25% from one site to another. Advisory exceedance was more variable, however, ranging from 7-10% to 27-40% in our three study sites. Fish consumption increased with age, education, and income, and was higher for nonwhites than for whites. Advisory exceedance was higher for women, nonwhites, and older anglers. At each site, the types of fish that contributed the most to advisory exceedance varied.
Conclusions: Community-specific (and resource-intensive) fish consumption guidelines are likely to benefit populations of urban anglers.

Summary of Section 6: Effects of an Advisory Brochure on Fish Consumption of Urban Anglers in the Great Lakes Region

Objective: Past research suggests that urban anglers are a group at high risk of being exposed to contaminants from fish consumption. Fish consumption advisories have been used in many regions to encourage healthy fish-eating behaviors, but few studies have been designed to assess whether these advisories actually influence behavior as intended. We conducted a large-scale, randomized experiment to test the influence of an advisory brochure on urban anglers' fish consumption.
Design: We collected detailed information on urban anglers' fish consumption in the summers of 2014 and 2015. We provided a treatment group with fish consumption guidelines in an advisory brochure before the summer of 2015 and compared their change in fish consumption to a control group.
Participants: We collected fish consumption data from a representative sample of 1,041 licensed anglers in the three counties containing Rochester, NY, Erie, PA, and Kalamazoo, MI.
Results: The brochure led to a reduction in fish consumption for anglers who ate the most fish; these anglers reduced their consumption of high-contaminant purchased fish and both high- and low-contaminant sport-caught fish. The brochure also reduced sport-caught fish consumption among those anglers who exceeded the advisories in 2014. In addition, the brochure led to small increases in fish consumption in urban anglers who ate very little fish.
Conclusions: Fish consumption guidelines brochures can have effects on target audiences. Future research that could improve our understanding of the effects of such interventions might assess the effects of brochure interventions on contaminant ingestion, explore the effectiveness of different delivery methods for brochures, or explore the effectiveness and cost-effectiveness of different types of interventions.

OUTPUTS AND OUTCOMES

This project produced a number of outputs that will contribute to longer-term outcomes. These outputs and outcomes are summarized here for both women of childbearing age and urban anglers.

Women of Childbearing Age (WCBA)

The principal outputs of the WCBA portion of the project were:

- We developed a set of print brochures intended to encourage women to eat fish, but to follow healthy fish-eating guidelines. These print brochures were informed by the results of past research, by a survey and a set of focus groups conducted as part of this project, and by the experience and insights of health professionals and staff members of state health departments and environmental agencies in the region.

- We collected detailed diary-based fish consumption information from women of childbearing age in the Great Lakes region over 4-month periods in the summers of 2014 and 2015. In 2014, 1,395 provided information on their fish consumption for the entire 4-month period. In 2015, 1,173 provided information for the entire period. Combining data from the two years, 1,135 WCBA provided information on their fish consumption for the entire 4-month period in both years.

- We estimated the number of WCBA eating fish in excess of recommendations and the number of WCBA eating less fish than is recommended to receive health benefits. Three to five percent of WCBA exceeded federal recommendations for total fish consumption, 0% exceeded federal recommendations for canned "white" tuna, and 4% consumed one or more meals of federal "do not eat" species. Rates of exceedance of state fish consumption guidelines, which include sport-caught fish, were much higher. One-quarter of WCBA exceeded the state guidelines, with rates as high as 41% exceeding the guidelines in Michigan and Minnesota. A total of 84-87% of WCBA ate less fish than was recommended by the USDA and (current and proposed) EPA/FDA guidelines to receive health benefits.

- The 1,135 women who completed fish consumption diaries throughout the 4-month periods in both years of the project were included in the experiment in which we tested the impacts of an advisory brochure on fish consumption. Approximately two-thirds of the women received one of four versions of the brochure, and the remaining one-third served as a control group. The brochure increased the amount of fish that women ate without increasing the number exceeding advisory recommendations. Therefore, it increased the number of women getting benefits from fish consumption without increasing the number at risk from fish consumption. Women who ate the least fish (< 0.7 meals/week at baseline) stood to benefit the most from increasing their fish consumption. In our study, women who ate < 0.7 meals/week of fish and received fish consumption guidelines with messages about the importance of eating fish ate more fish the next year. However, this benefit only occurred if they received messages in a "narrative" format (messages communicated as part of a story about a hypothetical woman of childbearing age); other forms of the guidelines did not influence fish consumption. These women increased their fish consumption largely by eating more low-mercury, purchased fish. These women did not increase their consumption of more contaminated fish.

- Women who ate too much fish (>2.8 meals/week at baseline) were also influenced by the narrative form of the brochure. They ate fewer meals after receiving the brochure, but did not decrease their consumption sufficiently to be within advisory recommendations.

The principal outcomes of this portion of the project were:

- We documented how healthy fish consumption and ingestion of toxic substances through fish consumption changed over the two-year course of this project in response to the advisory brochure (as described above).

- The principal outcome of this work was intended to be a reduction in the number of WCBA who eat Great Lakes fish in excess of recommended consumption guidelines and, therefore, accumulate toxic substances in their bodies. Our intervention did not lead to a reduction in the number of women eating purchased or sport-caught fish in excess of guidelines. It did, however, lead to an increase in fish consumption by WCBA without a corresponding increase in the number of WCBA exceeding the guidelines. Consequently, it increased the benefits women are getting from fish consumption without increasing the risks. Furthermore, a few women who were exceeding the recommended guideline of 2 meals per week decreased their consumption somewhat.

- Based on these findings, we estimate for every 10,000 narrative brochures distributed, 2,797-3,330 women of childbearing age would eat more fish, totaling 14,544-17,316 more fish meals each year. This increase in fish consumption would not result in any more women exceeding fish consumption guidelines. Furthermore, we estimate for every 10,000 narrative brochures distributed, 76-90 women of childbearing age who were currently exceeding fish consumption guidelines would eat fewer fish, totaling 1,011-1,197 fewer fish meals each year. These estimate are based on the fish consumption messages and methods of distributing the brochures used in this study. The distribution methods (and possibly the messages) used in advisory programs would differ.

Urban Anglers

The principal outputs of the urban angler portion of the project were:

- We developed a set of print brochures intended to encourage urban anglers to follow fish consumption guidelines. These print brochures were informed by the results of past research and by the experience and insights of health professionals and staff members of state health departments and environmental agencies in the region.

- We collected detailed diary-based fish consumption information from urban anglers living in three sites in the Great Lakes region over 4-month periods in the summers of 2014 and 2015. In 2014, 1,363 provided information on their fish consumption for the entire 4-month period. In 2015, 1,081 provided information for the entire period. Combining data from the two years, 1,041 urban anglers provided information on their fish consumption for the entire 4-month period in both years.

- We estimated the number of urban anglers eating fish in excess of advisory guidelines. Advisory exceedance ranged from 7-10% to 27-40% in our three study sites (with the range reflecting different assumptions). Advisory exceedance was higher for women, nonwhites, and older anglers.

- The 1,041 urban anglers who completed fish consumption diaries throughout the 4-month periods in both years of the project were included in the experiment in which we tested the impacts of an advisory brochure on fish consumption. Approximately two-thirds of the sample received one of four versions of the brochure, and the remaining one-third served as a control group.

- The brochure led to a reduction in fish consumption for anglers who ate the most fish; these anglers reduced their consumption of purchased fish, sport-caught fish, high-contaminant purchased fish and both high- and low-contaminant sport-caught fish. (We defined "high-contaminant fish" as those for which guidelines recommend fewer than one meal/week.) The version of the brochure did not matter.

- The brochure also led to a reduction in sport-caught fish consumption by those anglers who exceeded advisory recommendations in 2014. These anglers reduced their consumption of sport-caught fish compared to the control group by nearly 2 fish over the course of the summer.

- The brochure led to small increases in fish consumption in urban anglers who ate very little fish. These anglers increased their consumption of sport-caught fish and high-contaminant purchased and sport-caught fish. These increases in fish consumption came without increasing the number of anglers who were exceeding advisory recommendations.

The principal outcomes of this portion of the project were:

- The principal outcome of this work was intended to be a reduction in the number of urban anglers who eat Great Lakes fish in excess of recommended consumption guidelines and, therefore, accumulate toxic substances in their bodies. Our intervention led to a reduction in consumption of high-contaminant fish (fish for which guidelines recommend fewer than one meal/week) among anglers who ate the most fish.

- Based on these findings, we estimate for every 10,000 brochures distributed, the 1,948-2,452 anglers eating the most fish would reduce their consumption of high-contaminant fish by 6,457-8,127 meals each year. Similarly, the 2,504-3,048 anglers eating the most purchased fish would reduce their consumption of high-contaminant purchased fish by 4,780-5,818 meals each year, and the 1,120-1,532 anglers eating the most sport-caught fish would reduce their consumption of high-contaminant sport-caught fish by 3,381-4,625 meals each year. At the same time, high-consuming anglers would also reduce their consumption of low-contaminant sport-caught fish. The 2,133-2,651 anglers eating the most sport-caught fish would reduce their consumption of low-contaminant sport-caught fish by 5,629-6,996 meals each year. These estimates are based on the fish consumption

messages and methods of distributing the brochures used in this study. The distribution methods (and possibly messages) used in advisory programs would differ.

- Although high-consuming anglers would reduce their consumption of fish, anglers who ate very little fish would increase their consumption of high-contaminant fish. The 668-1,004 anglers who ate the least purchased fish would increase their consumption of high-contaminant purchased fish by 786-1,181 meals each year. The 3,661-4,255 anglers who ate the least sport-caught fish would increase their consumption of high-contaminant sport-caught fish by 4,023-4,675 meals each year. Because these anglers ate almost no fish initially, increasing their consumption of high-contaminant fish by these small amounts would pose very little risk to them. Thus, communication of fish consumption guidelines would allow anglers who were at low risk to take additional advantage of their opportunities to eat fish.

SECTION 1: USING A WEB-BASED DIARY METHOD TO ESTIMATE RISKS AND BENEFITS FROM FISH CONSUMPTION*

ABSTRACT: Accurate estimates of the amount and type of fish people eat are necessary to determine the health benefits and risks of consuming fish, and to assess compliance with fish consumption guidelines issued for fish affected by chemical contaminants. We developed a web-based and mobile phone-enabled diary methodology to collect detailed fish consumption information for two 16-week periods in the summers of 2014 and 2015. We recruited study participants from two populations living in the Great Lakes region – women of childbearing age (WCBA) and urban residents who had purchased fishing licenses. In this paper we describe the methodology in detail and provide evidence related to participation rates, the representativeness of our sample over time, and both convergent validity and reliability of the data collection methods. Overall, 56% of WCBA and 50% of urban anglers provided complete data across both data collection periods. Among those who provided information at the beginning of Year 2, 97% of both audiences provided information throughout the entire 16-week period. Those who participated throughout the two-year period were slightly older on average (1.9-2.5 years) than other members of our original samples. We conclude that using diaries with web and smartphone technology, combined with incentives and persistent communication, has strong potential for assessing fish consumption in other areas of the country or for situations where the potential risks associated with fish consumption are substantial and the cost can be justified.

KEYWORDS: diary method, fish consumption, Great Lakes

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1. Introduction

A large body of research has shown that some fish contain chemical contaminants, such as mercury and polychlorinated biphenyls (PCBs), that can be harmful to humans if consumed in large quantities, especially in children and women of childbearing age (WCBA) (e.g., Turyk *et al.*[1]: Papadopoulou *et al.*[2]). There are also benefits to consuming fish, as they are the primary dietary source of omega-3 fatty acids which are important for adult health,[3] as well as the development of eyes, brains, and nervous systems.[4] Federal, state, and tribal agencies provide guidelines for fish consumers on the safest amounts and types of fish to eat based on analyses of contaminants in fish from different waters.

It is important to know the species, the amounts, and the frequency with which people are eating fish in order to know if people are following these guidelines. If many people are exceeding federal, state and tribal recommendations, relevant agencies need to know how they can improve their outreach efforts so more people follow their guidelines. Reliable data about fish consumption are also needed for regulatory programs to use in their risk assessment processes.

Fish consumption has been measured using different methods which vary in terms of the amount and type of information collected, the timeframe over which data are collected, the period of recall for the respondent, respondent burden, and cost. They also vary in how well they address concerns about accuracy and representativeness. The methods used in the vast majority of studies can be grouped into two general types. The first type of method involves the use of a Food Frequency Questionnaire (FFQ) (e.g., How frequently do you eat tuna? Once a week, once a month, etc.). The FFQ method is easy to administer and generally low cost.[5,6] Nonetheless, it is an approximation and relies on a respondent's memory of dietary behavior and therefore raises concerns about recall bias and accuracy. Using the FFQ requires making assumptions about portion size to measure fish intake beyond number of meals. Furthermore, the FFQ may not collect information at the level of detail (e.g., waterbody origin or sub-species of the fish, such as albacore versus light tuna) needed in certain situations.

The second type of method is the use of a diet diary. This method asks respondents to record all food consumed, usually for three to seven days. Diet diaries provide more detail than FFQs. The "gold standard" diet diary method for measuring food consumption involves a researcher checking these diaries every day.[7] This places a heavy burden on both the respondent and the researcher, however, making it very costly to implement and therefore less feasible for widespread use. Such short-term diet diaries are also limited because they provide only a snapshot of a person's diet;[5] as a result, these short-term diary methods may not capture consumption of infrequently consumed items such as sport-caught (and potentially contaminated) fish. To overcome these limitations, researchers have used various combinations of these two methods, asking people to keep detailed short-term food diaries for 3, 4 or 7 days while also filling out a FFQ to cover a longer period of time.[8,9] These combination studies address some of the pitfalls of each method, but still rely on recall (and its potential bias) for infrequently consumed foods, and do not provide precise estimates of consumption of these foods.

Connelly and Brown[10] sought to address the need for detailed estimates of infrequently consumed fish meals by developing a longer-term diary method. They asked participants to record fishing trips and fish consumption over the course of a year in a paper diary. They contacted participants every three months by telephone to retrieve information recorded in the diary and encourage participation. This method allowed for the collection of information about fish rarely eaten and thus sought to reduce concerns about recall bias. Nevertheless, it raised concerns about representativeness of the data, with a limited number of people willing to participate in the long-term.

For these types of longer-term studies, researchers such as Adamson and Chojenta[11] have written about the importance of developing and maintaining relationships with participants to encourage response, lower attrition rates and maintain a representative sample. Laurie and Lynn[12] further concluded that the use of incentives was an important element in minimizing attrition in longer term studies. They acknowledge, however, limited available evidence about optimum incentive strategies.

Advances in technology now allow for web-based and mobile phone-enabled data collection. These methods may reduce research costs and perhaps respondent burden, but the impact on the representativeness of the sample is unknown. There is some evidence, however, that accuracy levels are maintained. Kissinger *et al.*[13] developed a computer-assisted personal interview software system for collecting tribal fish consumption data which allows a person to interview a respondent using a computer to record the information during the interview. The authors thought using the computer was better than paper and pen methods because it allowed for complex branching, no data entry errors (which are found in transcribing data from paper to computer), and no printing or mailing costs. Sharp and Allman-Farinelli,[14] in a review article that focused on the use of mobile phones to assess dietary intake, found no difference in validity or reliability between the use of mobile phones and conventional methods (i.e., pen and paper). Participants in the studies they reviewed reported higher satisfaction with and a greater preference for the mobile phone method. Similarly, Hutchesson *et al.*[15] found that among a small sample of young women aged 18 to 30 there was no difference in the accuracy of reported food consumption between diary methods administered by paper versus online or smartphone, but the women preferred the online or smartphone methods.

Considering this past research, we endeavored to develop a method to measure fish consumption accurately over time that included consumption of both purchased fish and frequently and infrequently eaten sport-caught fish from a variety of waters. Our approach was designed to minimize recall bias, keep respondent burden to a minimum, make use of web-based and mobile phone-enabled technology, and reduce attrition by the use of incentives. In this paper, we describe our methods in the form of a case study. We offer evidence of participation rates, representativeness of our sample over time, and both convergent validity and reliability of the data collection methods. We conclude with a reflection on the potential value of such a method for future collection of fish consumption data to inform consumption advisory efforts.

2. Methods

2.1. Study Context

The overall objectives of the study to which we applied our methods were to: 1) quantify fish consumption (species and amounts), 2) assess adherence to fish consumption guidelines, and 3) measure the effects of a fish consumption advisory brochure on fish consumption behavior. We chose two audiences to study. One audience was WCBA who had fishing licenses; because of their potential to bear children, this group may have both higher risks and higher benefits from fish consumption than other groups.[16] The second audience was urban anglers, who have long been thought to be at greater risk from fish consumption because they are more likely to fish urban waters that are heavily polluted and may contain fish that have accumulated industrial contaminants.[17] We conducted our research in the Great Lakes region where the Great Lakes Consortium for Fish Consumption Advisories has long-standing efforts to improve communication of fish consumption guidelines. We used a web-based and mobile phone-enabled diary method to collect fish consumption information for two 16-week periods in the summers of 2014 and 2015. Data collected during the first summer provided information for our first two objectives. Between the first and second summer we developed brochures containing different risk communication messages, which we sent to two-thirds of participants. One-third of participants formed a control group who participated fully in all data collection but did not receive an experimental brochure. We compared fish consumption data collected in the second summer to data collected in the first summer to assess the effectiveness of the risk communication messages (Objective 3). We monitored participation rates and the representativeness of our samples over time. In this paper, we evaluate the data-collection method but do not report results on the three main research questions which the method was designed to address since these findings are reported elsewhere.[18,19,20]

2.2. Sample Selection and Diary Recruitment

We used fishing license records to obtain the samples for both survey audiences. We drew a sample of 15,000 fishing licenses sold to women aged 18 to 48 (who would reach a maximum age of 50 [considered the end of the childbearing years] at the end of our two-year study) who lived in counties bordering the Great Lakes (i.e., Great Lakes coastal region). We drew the sample by state in proportion to the number of licenses sold in each state to WCBA who lived in the Great Lakes coastal region.

We selected three urban areas in the Great Lakes region for the urban angler portion of our study – Kalamazoo, MI; Erie, PA; and Rochester, NY (Figure 1). We drew a sample of 15,000 fishing licenses sold to anglers living in the counties containing the urban areas. We sampled an equal number of licenses (n=5,000) from each urban area.

We set recruitment quotas for each state or urban area based on the number of participants we estimated we needed at the end of the two-year study for sufficient power in our statistical analysis. The recruitment quotas were in the same proportions as the sample selection.

We sent invitation letters to each member of the sample in February 2014. The letter described the study and what would be required of participants and provided a link to a sign-up page on a website. We offered a financial incentive up to $20 for participation in the first year of the project, and up to $25 for participation in the second year. We provided a postage-paid return

postcard for people to opt out of the study because they did not eat fish, did not have regular internet access, or were not interested in participating. We sent a follow-up letter to all invitees a week later encouraging participation.

Fig. 1. Great Lakes study area. (Stars indicate location of urban angler study sites.)

We made telephone calls to those who did not sign up or return a postcard to encourage participation and allow sign-up directly over the telephone. Calling ceased in a particular area when the quota of participants had been reached for that area. During the study sign-up process we obtained email addresses and checked them by sending out a verification email. We then used email for all communication with study participants.

Before the start of data collection in Year 2 we sent an email to all participants who had provided data in Year 1. We asked them to verify their mailing address so we could determine if they still resided in the study area. Those who had moved out of the area were sent an email thanking them for their participation in Year 1, and indicating they were no longer eligible to participate in the study.

2.3. Diary Data Collection

We collected fish consumption information for 16 weeks from May 18 through September 6, 2014 and again from May 17 through September 5, 2015. Participants recorded data in two-week

blocks. Participants could record information as many times as they wished during the two-week period[1]. Every two weeks we sent an email invitation to participants with a direct link to their diary to signal the start of the next two-week period and remind them that the previous two-week period was ending. We also included occasional "tips," as recommended by Connelly and Brown (1996), for filling out the diary that addressed potential recording errors identified in preliminary data analysis. When a two-week period ended, we sent up to three reminders to participants who had not completed entering data for the period to finish recording their information for the period. Participants earned financial incentives ($2 per period) for each period completed and received a bonus at the end if they completed reporting for every period.

We gave each participant a unique link to access their personal fish consumption diary on a secure website. On the initial page, participants saw information for the eight two-week periods of the study, showing completed periods and incentives earned. On the next page we asked participants to record for each day in the current two-week period whether or not they ate fish, with a click on a "yes" or "no" radio button. For each day they indicated they ate fish, another page opened asking the number of fish meals they ate on that day. For each meal reported, participants recorded whether the fish was purchased (at a store or restaurant) or sport-caught (i.e., fish caught by you or someone else), the species eaten, the portion size, and (for sport-caught fish) where the fish was caught, using radio buttons. Figure 2 shows a screenshot of this page of the diary. We provided a list of fish species via a drop down menu, including the most commonly consumed purchased fish and specific purchased fish with consumption guideline recommendations, along with a text box to record other purchased-fish species not on the list. For sport-caught species, we listed only those with consumption guideline recommendations and provided an "other" option for species not on the list. Participants indicated portion size in reference to a picture of a 6 oz. cooked (8 oz. pre-cooked) portion of salmon; we asked participants if the meal they ate was larger, smaller, or the same size as the picture using the radio buttons next to the picture. In our analysis we made assumptions about the number of ounces and grams consumed when participants indicated their meal was smaller or larger than the picture. For WCBA, we assumed those indicating an equivalent portion to the photo ate a 6 oz. portion (170 grams). When participants indicated their portion size was larger than the picture; we assumed they ate 8 oz. (227 grams). For meals reported as being smaller than the picture, we used a sensitivity analysis to compare two options for calculating portion size. For one option, we estimated the smaller portion size to be 3 oz. (85 grams) and for the other we assumed the size to be 4 oz. (113 grams). For urban anglers, we again assumed those indicating an equivalent portion to the photo ate a 6 oz. portion (170 grams). When participants indicated their portion size was smaller than the picture; we assumed they ate 4 oz. (113 grams). For meals reported as being larger than the picture, we used a sensitivity analysis to compare two options for calculating portion size. For one option, we estimated the larger portion size to be 8 oz. (227 grams) and for the other we assumed the size to be 10 oz. (283 grams).

Fish consumption data gathered in the diary can be reported as number of meals, ounces, or grams consumed. These measures can be examined by time period (day, week, month, etc.), type of fish (purchased or sport-caught, species), location caught for sport-caught species, and socio-

[1] Appendix A provides information on how often participants recorded fish consumption information within a two-week interval.

demographic characteristics of participants. They can be compared to state and federal guidelines to measure adherence to those guidelines. Examples of the use of the data collected can be found in Connelly *et al*., [18] Connelly *et al*.,[19] and Lauber *et al*. [20]

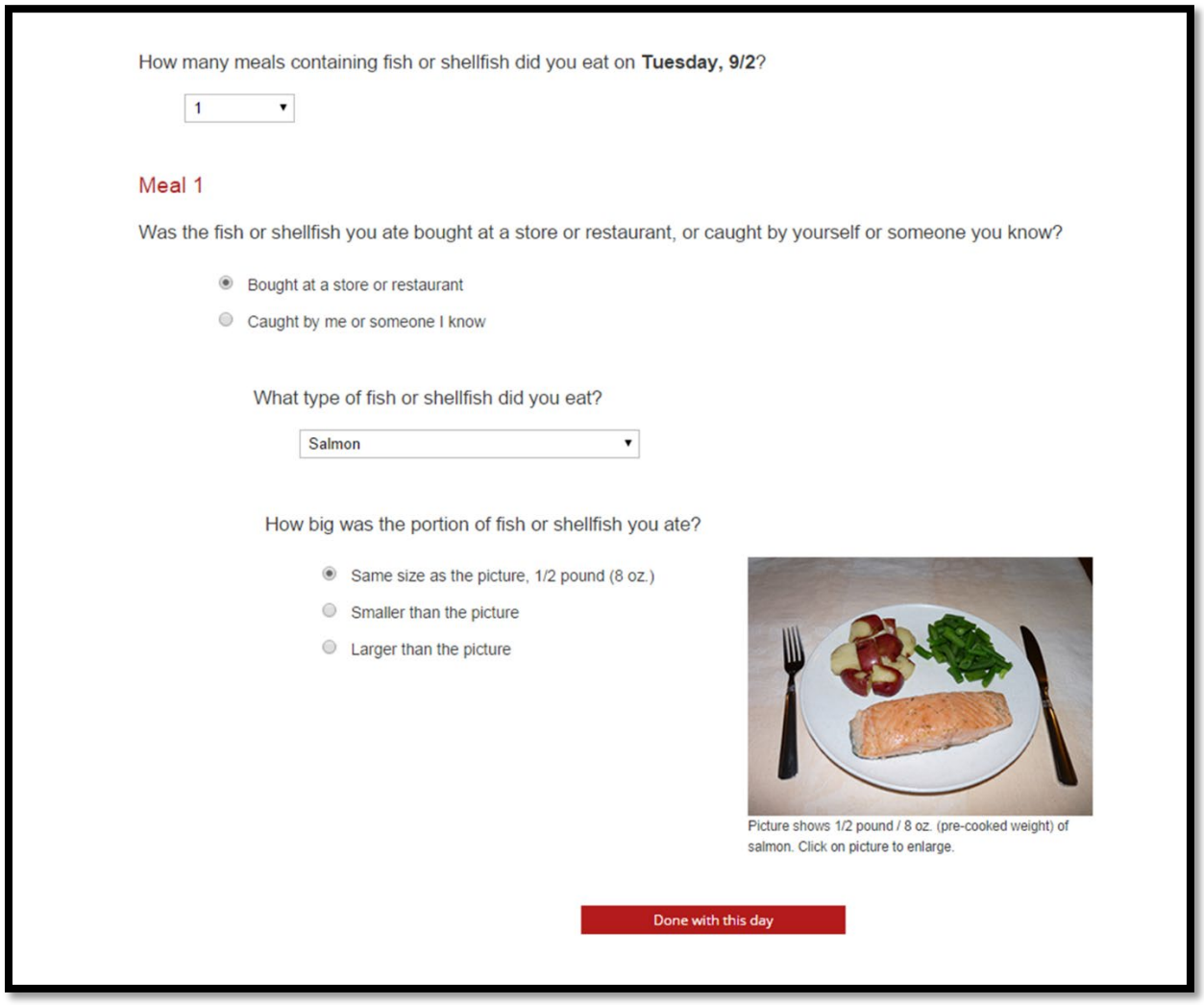

Fig. 2. Screenshot of diary page showing data recorded for a purchased fish meal.

2.4. Data Analysis

We analyzed data from the diary using SPSS (IBM SPSS Statistics 24). We obtained data on participant age and gender from fishing license records. We compared diary recruits and participants with those not recruited or participating using chi-square and t-tests to identify statistically significant differences at the $P < 0.05$ level. We tested for convergent validity by comparing perceived changes in fish consumption between Years 1 and 2 with actual changes in consumption using t-tests. We assessed test-retest reliability in the type and amount of fish eaten between Years 1 and 2 among the control group only (since the intervention had the potential to influence Year 2 consumption). We compared consistency between Years 1 and 2 at a gross level – eating or not eating certain types of fish, eating above or below the median, and eating above or below the top quartile. We also used inferential confidence intervals to statistically test

for the equivalence of means between Years 1 and 2, as described by Tyron[21] and illustrated by Muthusamy *et al.*[22]

3. Results

3.1. Initial Recruitment

We sent initial recruitment letters to 15,000 WCBA and 15,000 urban anglers. We made contact in some form (via direct web signup, postcard return, or telephone interview) with 4,185 WCBA and 5,384 urban anglers (Table I). Of those with whom we had contact, 48% of WCBA and 39% of urban anglers agreed to participate in the study. Fewer than 15% in each group were ineligible to participate because they did not consume fish at all. Fewer than 10% in each group were ineligible because they did not have an email account or internet access. Over one-third of those we had contact with in each group declined to participate in the study.

Table I. Results of recruitment efforts for WCBA and urban anglers.

	WCBA		Urban anglers	
	n	%	n	%
Communicated with via web sign-up, return postcard, or phone interview	4,185	100.0	5,384	100.0
Recruited	2,014	48.1	2,099	39.0
Ineligible – Do not eat fish	565	13.5	490	9.1
Ineligible – No email or web access	86	2.1	405	7.5
Refused to participate	1,520	36.3	2,390	44.4

Those who agreed to participate were slightly older than others in the original sample pool for both WCBA and urban anglers (Table II). There were no gender differences between urban anglers who agreed to participate and the remainder of the original sample pool. There were some differences between those who agreed to participate and those who were ineligible based on our criteria. WCBA who did not eat fish were younger than those who agreed to participate in the study. Urban anglers who did not have internet access were much older on average than those who agreed to participate. Urban anglers who refused to participate were also older on average than those who were recruited.

Table II. Comparison of those recruited with others in the sample by age and gender.

	WCBA	Urban anglers	
	Mean age	Mean age	% male
Recruited	35.6	47.6	83.0
All others in sample pool	33.7*	45.5*	83.1
Ineligible – Do not eat fish	34.0*	49.1	80.5
Ineligible – No email or web access	36.2	63.2*	84.5
Refused to participate	35.4	52.0*	85.6*

*Significantly different (at $P < 0.05$) from group recruited.

A total of 2,014 WCBA and 2,099 urban anglers consented to participate in the study. The number recruited in each stratum was similar to or exceeded the recruitment quota in 8 of the 11 strata (Table III). Michigan (WCBA and urban anglers) and Ohio WCBA proved more difficult to recruit from than the other states. The number recruited was 6-9% less than the recruitment quotas in Michigan and 17% less in Ohio.

Table III. Initial sample size, recruitment quota, and number recruited by study strata.

	Initial sample size	Recruitment quota	Number recruited
WCBA			
New York	2,178	290	360
Pennsylvania	228	30	34
Ohio	1,806	241	199
Indiana	556	74	73
Illinois	1,101	147	157
Michigan	4,860	648	608
Wisconsin	3,620	483	482
Minnesota	651	87	101
Urban anglers			
Kalamazoo, MI	5,000	667	610
Erie, PA	5,000	667	705
Rochester, NY	5,000	667	784

3.2. Participation in Year 1

We sent up to three reminder emails at the end of each two-week period to encourage participants to complete data entry for that period and qualify for the financial incentive offered for that period. The effectiveness of the reminder emails peaked in each period on the day the reminder email was sent (Figure 3); the number of participants responding to each reminder declined over time.

Participation was highest in the first two-week period for both WCBA and urban anglers (Figure 4). Participation declined after the first period, but remained steady over the remaining periods. Participation among urban anglers was consistently slightly 1ower than among WCBA.

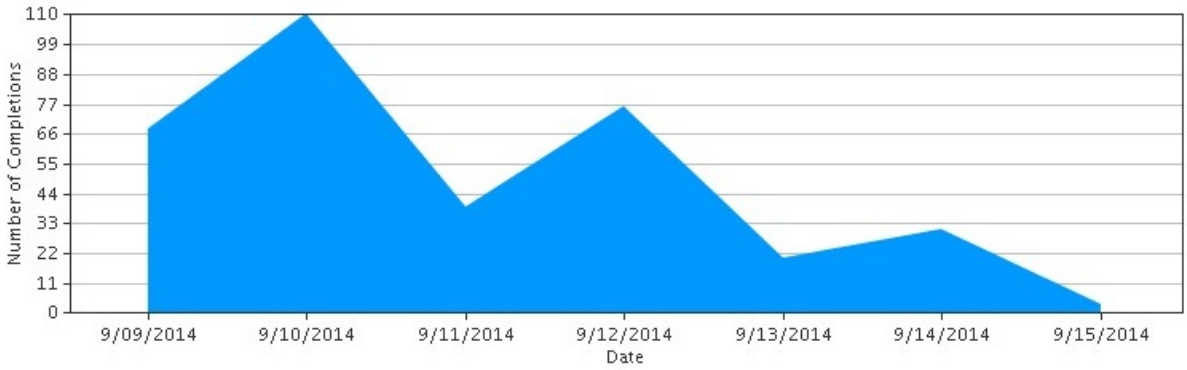

Fig. 3. Illustration of response peaks due to email reminders on 9/10, 9/12, and 9/14 (WCBA, eighth period, 2014).

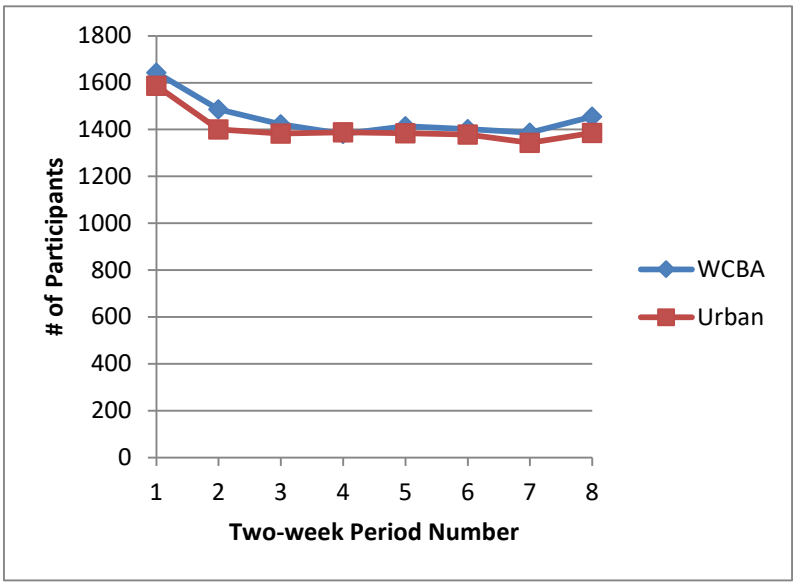

Fig. 4. Number of participants providing information in each two-week period of Year 1.

Participation rates (i.e., number providing information each period) were similar across strata, with slightly higher average rates among WCBA compared to urban anglers (Table IV). About 80% of WCBA and 76% of urban anglers participated in the first two-week period. The proportion decreased slightly over time, with between 65% and 75% of each stratum participating in the last two-week period of the first summer. At the end of the first year of data collection, among those who agreed to participate at the outset, 81% of WCBA and 79% of urban anglers provided some information, and 70% of WCBA and 66% of urban anglers provided information throughout the 16-week study period. A few participants (24 WCBA and 15 urban anglers) did not eat any fish during the 16-week study period. We did not include them in the analysis performed using Year 1 data but retained them as potential Year 2 participants because they indicated previously that they ate fish.

Table IV. Participation rates in diary by study strata.

	Percent		
	Participated in first two-week period	Participated in last two-week period	Participated in all periods
WCBA	80.5	71.3	69.6
New York	78.9	68.1	67.2
Pennsylvania	82.4	73.5	67.6
Ohio	81.4	73.4	73.4
Indiana	78.1	68.5	67.1
Illinois	79.0	70.1	70.0
Michigan	80.3	71.5	70.7
Wisconsin	82.8	73.4	72.6
Minnesota	83.2	73.3	68.3
Urban anglers	75.6	66.0	65.6
Kalamazoo, MI	78.5	68.9	68.7
Erie, PA	74.2	64.8	64.5
Rochester, NY	74.6	64.9	64.3

Using participants who ate at least one fish meal during the Year 1 study period, we compared those who participated in all periods (88% of WCBA and 85% of urban anglers) with those who participated in fewer (one to seven) periods. We found that WCBA who participated in all periods were slightly younger than those who participated in fewer periods (WCBA - 35.7 years old vs. 36.9 years old, p=0.042) and urban anglers who participated in all periods were slightly older than those who participated in fewer periods (Urban anglers – 49.0 years old vs. 46.1 years old, p=0.005). There were no gender differences between urban anglers who participated in all periods versus those who participated in fewer periods. For both target audiences, we found no differences in fish consumption between those who participated fully and those who participated during only part of the study period for the periods when the two groups overlapped.

3.3. Participation in Year 2

Before the start of data collection in Year 2 we contacted all participants who provided data in Year 1 and found very few WCBA (2%) and urban anglers (1%) had moved from the stratum area in which they had originally been selected. We excluded participants who had moved from Year 2 data collection.

Among all participants who provided data in Year 1 (and had not moved out of the study area or emailed us to say they did not want to participate in Year 2 [<1%]), 75% of WCBA and 69% of urban anglers participated in the first two-week period of Year 2. Of those who participated in the first two-week period, 97% of both WCBA and urban anglers participated in all remaining periods in Year 2.

Those who provided complete data in Year 1, regardless of study audience, were far more likely to provide complete data in Year 2 (Table V). Over 80% of WCBA and over 75% of urban anglers who provided complete data in Year 1 did so again in Year 2. Three-quarters of those in both audiences who provided partial data in Year 1 did not provide any data in Year 2.

Table V. Participation in Year 2 by WCBA and urban anglers who provided complete or partial data in Year 1.

	WCBA		Urban anglers	
	Provided complete data in Year 1	Provided partial data in Year 1	Provided complete data in Year 1	Provided partial data in Year 1
sample n	1,387	233	1,357	266
% providing complete data in Year 2	82.9%	16.3%	77.8%	14.3%
% providing partial data in Year 2	4.3%	8.1%	3.5%	9.8%
% not providing any data in Year 2	12.8%	75.6%	18.7%	75.9%

From among those who originally agreed to participate in the study, 56% of WCBA (1,135/2,014) and 50% of urban anglers (1,041/2,099) provided complete data throughout both Year 1 and Year 2. A few participants (15 WCBA and 14 urban anglers) did not eat any fish in Year 1 or Year 2. We did not include them in any of our fish consumption analysis, nor include them in the percentages calculated above for those providing complete data. Those who participated fully in both years were slightly older than others in the original sample pool for both WCBA and urban anglers (WCBA - 35.7 years old vs. 33.8 years old, $p<0.001$, Urban anglers – 48.2 years old vs. 45.6 years old, $p<0.001$). There were no gender differences between urban anglers who participated fully in both years and the remainder of the original sample pool (81.2% vs. 83.3% male, respectively).

3.4. Convergent Validity and Reliability

We found evidence of convergent validity between participants' beliefs regarding their change in behavior from Year 1 to Year 2 and their actual behavior. Those who thought they ate more fish meals in Year 2 than in Year 1 (both for purchased fish and sport-caught fish) also reported eating more in their fish consumption diaries (Table VI). Those who thought they ate fewer fish meals did in fact do so compared with those who did not think they changed their behavior.

Using only members of the control group, we also found strong evidence of test-retest reliability in the type and amount of fish eaten between Years 1 and 2. For example, over 90% of participants either ate purchased fish in both years or did not eat purchased fish in both years (Table VII). Less than 10% ate purchased fish in one year, but not the other. In a measure of the consistency in the amount of fish consumed in Year 1 versus Year 2, we compared those who ate above or below the median number of meals (based on Year 1 meals). We found that over 75% of participants were consistently above or below the median for measures of all fish, purchased fish and sport-caught fish. We found even higher percentages (>80%) of consistent behavior when comparing very heavy consumers (top quartile) with those who ate less fish. We also compared the inferential confidence intervals for all fish, purchased fish and sport-caught fish meals and found overlap in the intervals between Year 1 and Year 2 in all cases (Table VIII). Inferential confidence intervals are narrower than the standard descriptive confidence intervals

and provide good evidence for statistical equivalence ($p < 0.05$) between fish consumption in Year 1 and Year 2.

Table VI. Participant perception of change in the number of fish meals consumed between Year 1 and Year 2 and the average change in consumption based on diary data.

	WCBA	Urban anglers
Participant perception of change from Year 1 to Year 2*	Change in number of meals consumed	
Increased purchased fish meals		
No	-0.8	-0.5
Yes	3.4	2.9
Increased sport-caught fish meals		
No	-0.6	-0.8
Yes	0.2	1.6
Decreased purchased fish meals		
No	0.4	0.3
Yes	-4.6	-2.8
Decreased sport-caught fish meals		
No	-0.3	-0.4
Yes	-1.8	-2.2

*All comparisons between those saying "Yes" and "No" were statistically significantly different at $P<0.05$ using t-test.

Table VII. Consistency of consumption from Year 1 to Year 2, using members of the control group.

	WCBA	Urban anglers
	% consistent year to year	
Ate or did not eat		
Purchased fish meals	94	96
Sport-caught fish meals	78	79
Ate above or below median (based on Year 1 meals)		
All fish meals	81	83
Purchased fish meals	79	85
Sport-caught fish meals	77	78
Ate above or below top quartile (based on Year 1 meals)		
All fish meals	82	86
Purchased fish meals	86	87
Sport-caught fish meals	85	83

Table VIII. Mean fish consumption and 95% inferential confidence intervals (CI) for Year 1 and Year 2, using members of the control group.

	WCBA		Urban anglers	
	Mean	95% Inferential CI	Mean	95% Inferential CI
All fish meals-Year 1	14.67	13.99-15.34	17.02	16.61-17.87
All fish meals-Year 2	13.58	12.92-14.24	16.94	16.07-17.81
Purchased fish meals – Year 1	11.98	11.32-12.64	13.57	12.75-14.39
Purchased fish meals – Year 2	11.30	10.66-11.95	14.15	13.30-15.00
Sport-caught fish meals – Year 1	2.69	2.39-2.99	3.45	3.06-3.83
Sport-caught fish meals – Year 2	2.28	1.98-2.57	2.78	2.44-3.13

4. Discussion

4.1. Benefits of the Web-based Diary Method

We recruited over 2,000 people in each target audience to participate in a two-year study where they had to record their fish consumption online for 16 weeks each summer. We offered a modest financial incentive as suggested by others[12] and made efforts to reduce respondent burden by giving participants a direct link to their personal diary, using radio buttons and drop down menus to reduce recording time, and using mobile phone-enabled technology as preferred by participants in other studies.[14,15] The nature of the data we sought to collect (bi-weekly reports of fish consumption over two 16-week periods) reflects a substantial respondent burden. Nonetheless, half or more of the people we recruited initially participated fully throughout the two-year period (56% of WCBA and 50% of urban anglers), suggesting that this method was not too burdensome to a large subset of those who initially agreed to participate. This rate of full participation exceeds the 43% rate reported by Connelly and Brown[10] in their one-year study of fish consumption using a paper diary method.

The final, full-participation sample was not a perfect snapshot of the broader populations, but differences we could detect were relatively modest. In both audiences, those who participated throughout the two-year period were older on average (1.9-2.5 years) than other members of our original sample. However these differences, while significant due to the large sample size, were small in a practical sense. Also in our urban sample, we found no difference in the proportion of men versus women who participated throughout the two-year period compared to other members of our original sample. Based on findings from other studies,[23,24] it is likely that participants in our study underrepresent racial minorities and those with lower education and income levels, but we have no way to test the degree to which this might be occurring in our sample because we do not have comparable population data. It is also possible that interest in the study topic may have attracted more avid anglers and those within the angler community more likely to eat fish, but again we have no way to test the degree to which this might have occurred.

Over three-quarters of those who participated fully in Year 1 (78-83%) participated fully in Year 2. An astonishing 97% of participants who provided information at the beginning of the second summer provided information throughout the entire summer. The level of commitment of participants in our study was clearly high. We attribute this commitment in part to the incentive, but also to the persistent communication with an email every two-weeks and up to three reminders at the end of each two-week period encouraging participation. Our results seem to

confirm the recommendation of Adamson and Chojenta[11] regarding the importance of establishing a relationship with participants.

This longer term diary method (16 weeks) implemented during late spring through summer when the most sport-caught fish are typically consumed[25] is likely to provide more precise measurement of the number of sport-caught fish consumed, the species, and the location where they were caught than other methods (like FFQs) which rely on estimates such as "one per month." The type of detailed fish consumption information we collected, which has been viewed as a major challenge to researchers,[26] allows direct comparison with fish consumption guidelines and identification of individuals exceeding the guidelines. For example, we found that 7% to 40% of urban anglers exceeded their state's fish consumption guidelines,[20] exposing them to risks from consumption of chemical contaminants. Similarly, we found 25% to 28% of WCBA exceeded their state's fish consumption guidelines.[19] We also found that only 10 to 12% of WCBA reported eating within the federally recommended range of 8 to 12 oz. of fish per week, with 84-87% eating less than the recommended amount, suggesting they are not eating enough fish to maximize the potential for health benefits.[18]

We found some evidence for the convergent validity and test-retest reliability of the data collection method we used. In terms of convergent validity, participants who thought they had increased their consumption between years (measured in a post-Year 2 diary survey) also reported greater consumption in their Year 2 versus Year 1 diary, and those who reported they ate less fish on the survey also reported lower consumption via the diaries. The act of filling out the diary may have made people more aware of changes in their fish consumption, but these tests still provide evidence that we were measuring closely-related constructs.[27] We also found consistency and statistical equivalency in the types and amounts of fish consumed between years among the control group, suggesting that the test-retest reliability of data collected year to year was high.

Few people moved out of our study areas between Year 1 and Year 2. This suggests that concern about loss of sample due to changing residences need not be a major concern when estimating initial sample size requirements in a multi-year survey, at least in this Great Lakes region.

4.2. Limitations of the Method

The most substantial limitations of this method are the costs of implementation and the technical capability required to program the website for respondent use. We needed an experienced web programmer to develop each page of the diary, and time was required to test and retest all elements of data collection. While the costs associated with the administration of the diary were not high because much of the administration was automated through the website programming, the costs (in descending order of magnitude) of recruiting participants via mail and telephone, the completion-incentive payments, and the development of the website were significant. The research team deemed one of the purposes of the study, to measure actual behavior change as a result of risk communication messages provided experimentally via brochure, to be important enough to justify the costs. However, these methods may not be worth the time, effort, and money for research goals that do not require precise measurement of the number, species, and source of fish meals.

Internet access is generally available to most Americans; 84% have access in a 2015 Pew Research Poll.[28] Lack of access was a limitation to only a few of our potential participants (2% of WCBA, 8% of urban anglers), but precluded participation by some older anglers, especially in the urban angler sample. Nevertheless, the final group of participants was older than other members of the original sample. The tendency of older people to be more likely to respond to survey requests[29,30] seems to have outweighed the tendency of web-based surveys to attract younger respondents.[31,32]

4.3. Conclusions

The web-based and mobile phone-enabled diary method allowed us to gather detailed measures of fish consumption over a sustained period of time. This method provided us with often difficult to obtain information on fish consumed, including specific species, amounts, frequency and locations where they were caught; this type of information is necessary to accurately assess adherence to fish consumption guidelines. Those who participated fully over the two year period were demographically similar to those who comprised the original sample (based on available measures). The primary limitations of this method are the large cost associated with recruitment and incentive payments, and the technological skill required for programming the web-based diary. Nevertheless, the use of web and smartphone technology, combined with incentives and persistent communication, appears to have strong potential for use to assess fish consumption in other areas of the country or for situations where the potential risks associated with fish consumption may be substantial and the cost of a detailed diary approach can be justified.

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SECTION 2: FISH CONSUMPTION AMONG WOMEN ANGLERS OF CHILDBEARING AGE IN THE GREAT LAKES REGION*

ABSTRACT: Fish consumption advisories are issued by the federal government for women of childbearing age (WCBA). These advisories make recommendations about the amount and types of fish that should be consumed to provide the greatest health benefits to women and their children while avoiding risks from chemical contaminants. We used diary methods to study fish consumption patterns of 1,395 WCBA in the Great Lakes coastal region who purchased fishing licenses, a group which has significant opportunity to eat larger quantities of fish. Very few members of this group reported exceeding the federal recommendations for total fish consumption (between 3% and 5% depending on assumptions about portion sizes), consumption of canned "white" tuna (0%), or consumption of "do not eat" species (4%). They did report eating more fish on average than recent national study estimates, but they did not report consuming as much fish as is recommended to obtain the greatest health benefits of fish consumption. Only 10 to 12% of study participants reported eating within the recommended range of 8 to 12 oz. of fish per week, with 84-87% eating less than the recommended amount. Additional efforts are likely needed to encourage WCBA to eat more low-risk fish, even among this group of higher-than-average fish consumers.

KEYWORDS: fish consumption; fish consumption guidelines; anglers; risk communication; women of childbearing age

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1. Introduction

Fish consumption advisories are issued by state, federal, and tribal agencies in part because of the potential health risks to women and their children from a variety of chemical contaminants (Turyk et al., 2012: Papadopoulou et al., 2014). These advisories recommend that women of childbearing age (WCBA) limit their consumption of certain fish. At the same time, many of these agencies recommend that women consume more low-risk fish, especially during and after pregnancy, emphasizing fish with lower concentrations of chemical contaminants, particularly mercury. Fish are the primary dietary source of omega-3 fatty acids, which are important for adult health (Domingo, 2014) as well as the development of eyes, brains, and nervous systems in the fetus (Innis, 2008).

Several agencies within the federal government offer advice to women. The United States Department of Agriculture (USDA) advises that "women who are pregnant or breastfeeding consume at least 8 and up to 12 ounces of a variety of seafood per week, from choices lower in methyl mercury" (USDA, 2010, p. 39). Current Environmental Protection Agency/Food and Drug Administration (EPA/FDA) advice suggests that WCBA "eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury" (USEPA, 2004, p.1). However, EPA/FDA are in the process of revising their recommendations to more closely follow the USDA advice. The draft advice proposed by the EPA/FDA suggests that WCBA "eat 8 to 12 ounces of a variety of fish each week" from choices that are lower in mercury (USFDA, 2014, p. 1). The key difference is a change from suggesting it is permissible for WCBA to eat *up to* 12 ounces to suggesting women *should* eat 8 to 12 ounces. This change encourages consumption.

Advice from all federal agencies suggests that WCBA limit their consumption of certain fish that are higher in mercury. The recommendation is to limit canned "white" tuna consumption to 6 oz. per week, and avoid consumption of four species of fish (swordfish, shark, tilefish, and king mackerel).

While all states offer advice about consumption of fish caught by anglers within state waters, some states also offer advice regarding purchased fish. This advice generally follows the federal recommendations but offers more details and suggestions about specific species to consume (e.g., MDHHS, n.d.). Some states provide more conservative advice than the federal government, particularly for the consumption of canned "white" tuna. For example, Minnesota and Wisconsin suggest one serving per month (MDH, n.d.; WDHS, 2008) compared to the federal advice of 6 oz. per week.

Several studies have found that most WCBA avoid consumption of the most contaminated fish (Lando et al., 2012; Silver et al., 2007), however they do not seem to be following the advice encouraging consumption of low-risk fish and therefore may be missing out on the benefits of fish consumption for themselves and their offspring. Connelly et al. (2014) found that almost all new mothers consume less fish during pregnancy than was recommended by USDA. Similarly, Lando et al. (2012) found in a national survey that on average, all major demographic groups of women, but especially pregnant women, ate less fish than was recommended. Among women who ate fish, the median intake was 1.8 oz/week for pregnant women, 2.5 oz/week for postpartum women, and 3.0 oz/week for WCBA who were not pregnant or postpartum. Each of

these medians is far below the recommended 8 to 12 oz/week. Mahaffey et al. (2009) used National Health and Nutrition Examination Survey (NHANES) data from 1999-2004 to examine fish consumption patterns of WCBA (and their association with blood mercury levels). They found that WCBA in the Great Lakes coastal region ate less than 1 meal/week of fish on average, far below the recommended 2 meals/week. Based on more recent NHANES data (2009-2010), among those who ate fish nationwide, 60% ate less than 0.75 meals/week and 40% ate 0.75+ meals/week (EPA, 2013). A survey of Great Lakes states' residents found that among the 83% of women who ate fish, 6% consumed more than 2 meals per week, 14% consumed 1 to 2 meals/week, and the remaining 80% consumed less than 1 meal/week (Imm et al., 2005). None of these studies specifically examined the fish consumption patterns of women who fish, however. Women anglers likely have additional opportunities to consume fish, including potential exposure to additional chemical contaminants found in the fish they catch. Their consumption rates are likely to be higher than women who do not fish. Knobeloch et al. (2005) found that women who lived in a household where someone had a fishing license did eat more meals of sport-caught fish. Therefore, they may be more likely to get the benefits as well as be exposed to the risks of fish consumption.

We studied WCBA in the Great Lakes coastal region who purchased fishing licenses (and therefore have the opportunity to fish legally). Specifically, we recruited WCBA anglers who indicated that they consumed fish at least occasionally to participate in a diary study in which they reported their fish consumption behaviors. Because our objective was to describe the fish consumption habits of WCBA anglers living in this region, we did not include WCBA who did not eat fish. Among fish-consuming WCBA, this angler WCBA group may be likely to have higher levels of fish consumption than typical WCBA. Specifically, we examined how much and what types of fish they reported consuming and compared these levels with the USDA and (current and proposed) EPA/FDA recommendations.

2. Materials and methods

2.1 Sample selection and diary recruitment

We drew a sample of 15,000 fishing licenses sold to women aged 18 to 48 (who would reach a maximum age of 50 [considered the end of the childbearing years] at the end of our two-year study[2]) who lived in counties bordering the Great Lakes (i.e., Great Lakes coastal region). We drew the sample by state in proportion to the number of licenses sold in each state to WCBA who lived in the Great Lakes coastal region[3].

We sent invitation letters to each member of the sample in February 2014. The letter described the study and what would be required of participants. It also offered a financial incentive up to $20 for participation in the project, and provided a link to a sign-up page on the Internet. We provided a postage-paid return postcard for people to opt out of the study because they did not eat fish, did not have regular Internet access, or were not interested in participating. We sent a follow-up letter to all invitees a week later encouraging participation.

[2] We report only data from the first year of the study in this paper.

[3] Appendix B provides information on results from a special sample of Minnesota WCBA who were recruited as part of another research project and not included in the results of the main body of this report.

We made telephone calls to those who did not sign-up or return a postcard to encourage participation and allow sign-up directly over the telephone. Calling ceased in a particular state when the quota of participants had been reached for that state. During the study sign-up process we obtained email addresses and then checked them by sending out a study participation verification email. Email was then used for all communication with study participants.

2.2 Diary data collection

We collected fish consumption information for 16 weeks from May 18 through September 6, 2014. Participants recorded data in two-week blocks. Participants could record information as many times as they wished during the two-week period. Every two weeks we sent an email invitation to participants to signal the start of the next two-week period and remind them that the previous two week-period was ending. When a two-week period ended, we sent up to three reminders to participants who had not completed entering data for the period to finish recording their information for the period. Participants earned financial incentives for each period completed and received a bonus at the end if they completed reporting for every period.

We gave each participant a link unique to them to access their personal fish consumption diary on the Internet. On the initial page, participants saw information for the eight two-week periods of the study, showing completed periods and incentives earned. On the next page we asked participants to record whether or not they ate fish on each day in the current two-week period. For each day they indicated they ate fish, another page opened asking the number of fish meals they had eaten on that day. For each meal reported, participants recorded whether the fish was purchased (at a store or restaurant) or sport-caught (i.e., fish caught by you or someone else), the species eaten, the portion size, and (for sport-caught fish) where the fish was caught. We provided a list of fish species, including the most commonly consumed purchased fish and those with consumption guideline recommendations, along with a text box to record species not on the list. For sport-caught species, we listed only those with consumption guideline recommendations and provided an "other" option. Participants indicated portion size in reference to a picture of a 6 oz. cooked (170 grams) portion of salmon (Fig. 1); we asked participants if the meal they ate was larger, smaller, or the same size as the picture.

We obtained data on participant age from fishing license records. We gathered data on other socio-demographic characteristics, such as education and race, using an online survey conducted during the last 2-week period of diary data collection[4].

2.3 Data analysis

Several previous studies have estimated the size of fish portions that people consume using pictures similar to those used in our study (Connelly et al., 1996; West et al., 1989) or plastic models (Silver et al., 2007). Since we provided a picture of a 6 oz. cooked salmon meal, we assumed those indicating an equivalent portion to the photo ate a 6 oz. portion (170 grams). For 14% of meals, the participants indicated their portion size was larger than the picture; we assumed they ate 8 oz. (227 grams). For meals reported as being smaller than the picture (47% of meals), we used a sensitivity analysis to compare two options for calculating portion size. For one option, we estimated the smaller portion size to be 3 oz. (85 grams) and for the other we

[4] We did not ask if they fished during the study period.

Fig. 1. Picture shows a 6 oz. piece of cooked salmon (8 oz. pre-cooked).

assumed the size to be 4 oz. (113 grams). We used these estimates to convert from the number and size of meals to an estimate of ounces and grams consumed per week or per day.

We analyzed data from the diary using SPSS (IBM SPSS Statistics 20). We used chi-square tests to identify statistically significant differences between states at the $P < 0.05$ level. Any differences described in the narrative text are statistically significant at this level. We used Scheffe's test to identify differences in portion sizes based on species of fish consumed. We used linear regression to explain differences in fish consumption based on available demographic data.

We report state-specific data unweighted so these values reflect the number of WCBA who participated from that state. We weighted all other reported data in proportion to the number of fishing licenses sold to WCBA in the Great Lakes coastal region of each state. Weighting factors ranged from 0.85 to 1.17.

3. Results

3.1 Diary recruitment and participation rates

We recruited 2,014 WCBA to participate in the study. Women who agreed to participate were slightly older (35.5) than other women in the sample pool (33.7, $p<0.001$). Participation in the first two-week period was 80%. The number who participated throughout the 16-week study period was 1,419 (70%). WCBA were selected to participate in this study because they indicated that they ate fish at least occasionally. However, a few participants (n=24) reported that they did not consume any fish during the 16-week study period and were thus excluded from the analysis. We found no differences in fish consumption between those who participated fully and those who participated during only part of the study period for the periods when the two groups overlapped. Women of childbearing age who participated the entire 16 weeks were slightly younger than those who did not (35.7 vs. 36.9, $p=0.042$). Since these differences were substantively small, we considered WCBA who participated throughout the 16-week period as similar to all women who participated in the study and report results for the 16-week group only (n=1,395).

By design, women in our study ranged in age from 18 to 48. The average participant was 36 years old. Most were white (95%) and half (52%) reported they had a college degree. The median household income was in the $50,000 to $75,000 range. Eleven percent reported earning less than $25,000 per year, and 7% reported earning more than $150,000. Half of the participants (51%) reported having children 15 years of age or younger living in their household.[5]

3.2 Fish consumption

3.2.1 Types of fish eaten

Participants consumed over 20,000 meals during the 16-week study period, of which the vast majority (82%) were purchased fish (i.e., fish purchased at a store or restaurant). The proportion of meals from sport-caught fish (i.e., caught by the WCBA angler or someone they know) varied by state, with the lowest proportion of sport-caught meals consumed in Illinois and the highest proportion consumed in Minnesota (Fig. 2).

WCBA consumed a variety of purchased fish and shellfish (Table 1)[6]. Most of the more frequently eaten species, such as shellfish and salmon, are considered to have low mercury levels. (We defined "low mercury level" as <0.05ppm, which is equivalent to the unrestricted category in the Great Lakes protocol [McCann et al., 2007]. Mercury concentrations in fish were taken from the FDA list of commercial fish and shellfish [FDA, 2014]). Species low in mercury, highlighted in bold type in Table 1, comprise roughly two-thirds of meals consumed. Shellfish (e.g., shrimp, crab, scallops, and clams) alone comprise about one-third of purchased meals consumed. Shellfish consumption was particularly common among New York and Ohio WCBA (35% of meals) but less so among Minnesota WCBA (26%). Salmon, canned "light" tuna, canned "white" tuna, and cod were among the other most frequently consumed fish. Canned tuna, both varieties, was particularly common in Minnesota ("light" 18% and "white" 11% of meals). Canned "white" tuna was also somewhat common in Indiana (11%), but less so in Ohio (5%). Cod made-up a greater proportion of meals in Wisconsin (15%) than in the other states. Haddock, while not commonly eaten in most states, was most frequently eaten in New York (12% of purchased meals consumed).

The average portion size varied considerably by type of fish (Table 1). Canned tuna, both varieties, were the smallest in average portion size. Fish sticks/fast food sandwiches, shellfish, and tuna (not canned) portions were slightly larger. Salmon, the most commonly consumed single species, was intermediate among the types of fish examined, but average portion size was still smaller than the 6 oz. picture shown to participants. Women reported eating sport-caught fish and purchased haddock, perch, and catfish in significantly larger portions, averaging close in portion size to the picture shown.

[5] At the end of the study, we asked about pregnancy and breastfeeding status during the study period. Only 53 of the 913 respondents to the question indicated they were pregnant or breastfeeding during the period. We concluded the sample size was too small to assess how pregnancy and breastfeeding influenced fish consumption.

[6] Appendix C characterizes the number of types of purchased fish that individuals consume.

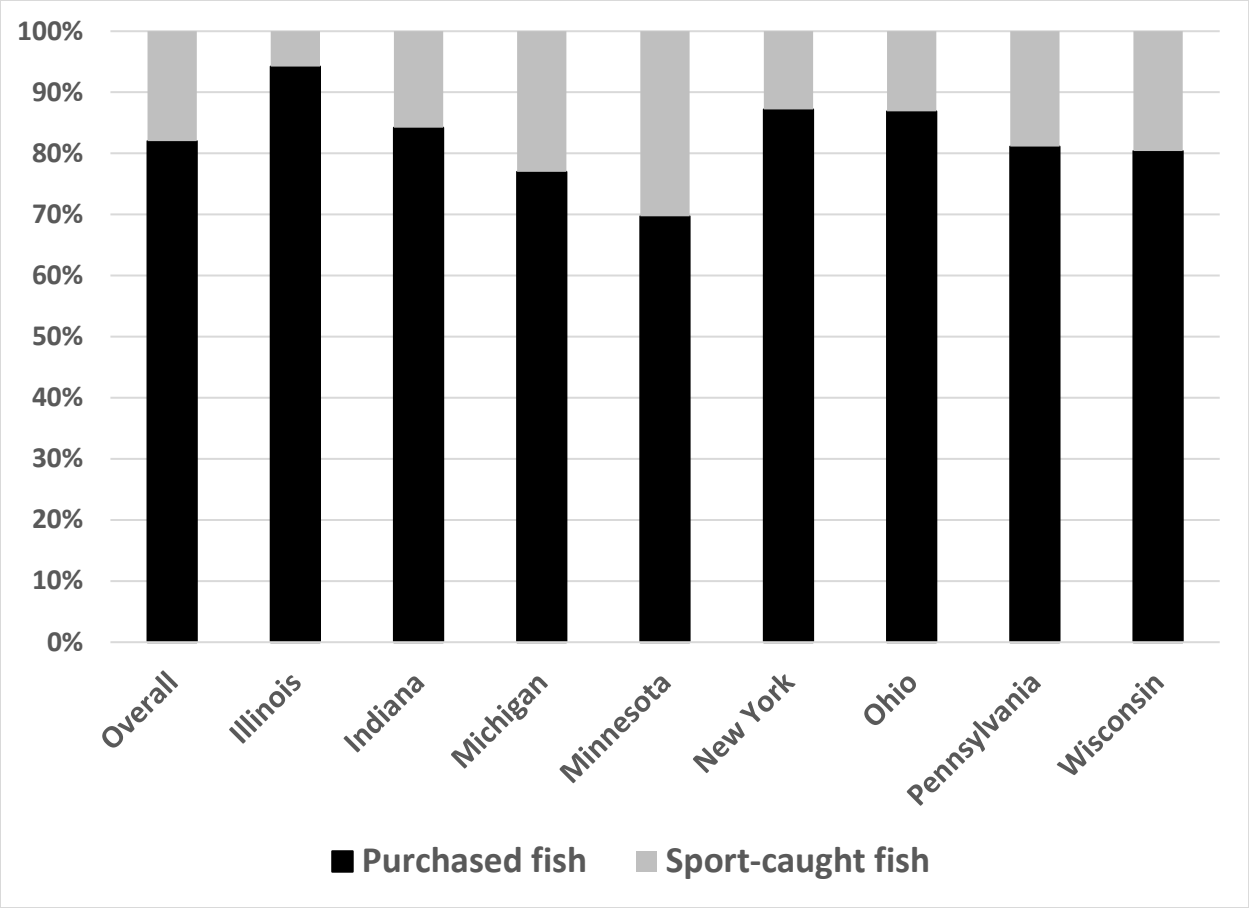

Fig. 2. Percentage of meals that were purchased versus sport-caught, overall and by state (Statistically significant difference between states at $p \leq 0.05$ using chi-square test).

3.2.2 Amount of fish eaten

The number of meals reported eaten during the 16-week period ranged from 1 to 92. The median was 12 meals or 0.75 meals/week. The average was 0.93 meals/week and did not differ by state of residence. A regression model using available demographic data showed that consumption increased as age and education level increased (adj. $R^2 = 0.041$, Table 2). Consumption was also higher among non-white WCBA and those without children age 15 or younger living in the household. Using the model coefficients to predict levels of consumption among the demographic groups reporting the highest fish consumption, the model predicts that older, highly educated, non-white women without children living at home averaged 1.5 fish meals/week.

Table 1
Percent of purchased meals and portion sizes for all meals by type of fish eaten (bolded species are considered low in mercury).

Type of Fish Eaten	% of purchased meals	Portion Size (Grams) based on*	
		3, 6, 8 oz. (85,170,227 grams)	4, 6, 8 oz. (113,170,227 grams)
Shellfish	30.4	131[c,d,e]	146[c,d]
Salmon	13.6	138[d,e,f]	150[d,e]
Canned "light" tuna	9.7	103[a]	125[a]
Cod	7.8	155[g,h,i]	156[f,g,h]
Canned "white" tuna	7.6	109[a,b]	129[a,b]
Tilapia	5.5	144[e,f,g]	154[d,e,f]
Fish sticks/fast food sandwiches	3.9	121[b,c]	138[b,c]
Haddock	3.1	163[i]	171[h]
Tuna (not canned)	2.7	130[c,d]	144[c,d]
Catfish (farm-raised)	1.4	161[i]	169[h]
Perch (purchased)	1.0	160[i]	168[h]
Other types of purchased fish	13.3	145[f,g,h]	163[e,f,g]
Sport-caught	N/A	157[h,i]	166[g,h]

* Used two options for calculating portion size if the participant indicated the meal was smaller than the 6 oz. portion pictured. Assumed 8 oz. if they indicated the meal size was larger.
[a-h] Values without a letter in common are significantly different from each other at p = 0.05 using Scheffe's test.

When portion size was factored in, WCBA anglers in the Great Lakes region reported consuming on average between 18.3 (using a more conservative assumption) and 20.1 (using a more liberal assumption) grams per day (g/day). As with the number of meals, the average grams per day consumed did not differ by state of residence. However, individual daily fish consumption varied considerably, with half of the WCBA eating 15.2 to 17.2 g/day or less (Table 3). Ten percent of WCBA consumed more than 35.4-38.4 g/day, almost double the average daily consumption; 1% consumed more than 67.8-73.3 g/day.

Table 2
Demographic predictors of fish consumption (meals/week).

Variable	Coefficient	*p*-value
Intercept	0.81	<0.001
Race[a]	- 0.29	<0.001
Age	0.01	<0.001
Child age 15 or younger in household[b]	- 0.21	<0.001
Education[c]	0.03	0.026

[a]Dummy variable (1=white, 0=non-white).
[b]Dummy variable (1=child age 15 or younger living in the household, 0= no child age 15 or younger in household)
[c]Education level was measured on a 6-point scale from 1=less than high school to 6=graduate degree. Income was also a significant predictor, but dramatically reduced the sample size if included in the model. It was highly correlated with education (0.31).

Table 3
Individual average daily fish consumption for WCBA who were at each consumption percentile.

Percentile of Women of Childbearing Age (WCBA)	Grams per day based on portion sizes of*	
	3, 6, 8 oz. (85,170,227 grams)	4, 6, 8 oz. (113,170,227 grams)
25%	8.9	10.1
50%	15.2	17.2
75%	24.0	26.3
80%	27.1	29.9
90%	35.4	38.4
95%	42.3	46.0
99%	67.8	73.3

* Used two options for calculating portion size if the participant indicated the meal was smaller than the 6 oz. portion pictured. Assumed 8 oz. if they indicated the meal size was larger.

Fish consumption patterns of those eating the most fish differed little from those eating fewer meals. Those eating the most fish (top 10%) did not eat more fish that the federal government recommends against eating than those who ate fewer fish meals. They consumed slightly more

meals from species low in mercury than those who ate fewer fish meals (56% versus 50% of fish meals), and somewhat fewer sport-caught fish (16% versus 19% of fish meals)[7].

3.2.3 Adherence to federal guidelines

EPA/FDA guidelines recommend that WCBA eat up to 12oz. of a variety of fish and shellfish each week. Assuming 6 oz. is a standard meal size, this recommendation is for up to two meals per week. Few women in our study reported consumption levels exceeding the recommendation by any of the metrics we used (Table 4). Five percent reported consumption levels exceeding the recommendation based on the number of meals consumed. Three to four percent exceeded the recommendation based on portion size.

The federal guidelines also recommend that WCBA eat no more than 6 oz. of canned "white" tuna per week. Although 29% of women in our study ate canned "white" tuna during the study period, none reported consuming more than the recommended amount. Consumption varied somewhat by state of residence, with Minnesota women who ate canned "white" tuna consuming twice as much per week as New York women (1.7 versus 0.7 oz. per week).

Table 4

Percent of WCBA in each meal category using three measures of fish consumption.

	Measures of fish consumption		
Meals (oz.)/week	# of meals	3, 6, 8 oz portion size	4, 6, 8 oz portion size
0.5 (3oz.) or less	29.3	38.9	33.6
0.51 (>3oz.) to 1.0 (6oz.)	36.6	36.5	38.0
1.01 (>6 oz.) to 1.5 (9oz.)	18.9	15.5	17.0
1.51 (>9oz.) to 2.0 (12oz.)	10.0	6.0	7.7
2.01 (>12oz.) to 2.5 (15oz.)	2.4	1.8	1.9
2.51 (>15oz.) or more	2.8	1.3	1.8

Very few WCBA in our study (4%) ate fish that the federal government recommends against (i.e., swordfish, shark, tilefish, king mackerel). Swordfish was the most commonly consumed "do not eat" fish, followed by shark. Only one participant reported eating tilefish, and none reported consuming king mackerel. Among women who ate these fish, 78% reported eating only one meal of the "do not eat" fish during the 16-week study period.

Federal and state advisories also discuss the benefits of fish consumption. Current EPA/FDA guidelines suggest women eat up to two meals of fish lower in mercury per week to receive the benefits. While at least two-thirds of the fish consumed are species considered low in mercury, Table 4 shows that most WCBA did not consume the recommended amount of fish (i.e., 2 meals per week). The vast majority of women ate less than 1.5 meals per week (85%), and most ate less than 1 meal per week (66%). Only 12% reported eating in the range of 2 meals per week (1.5-2.5

[7] Appendix D profiles the top 10% of fish consumers in more detail.

meals). The USDA and the proposed EPA/FDA guidelines suggest that WCBA consume between 8 to 12 oz. of fish per week. Only 10-12% of our study participants reported eating fish within that range.

4. Discussion and Conclusions

Our findings suggest several implications for communicating with WCBA about fish consumption to gain desirable health benefits while guarding against health risks from chemical contaminants in fish. Messages about the healthiest fish to consume should be tailored to locally popular fish, whether sport-caught or purchased. Species of purchased fish consumed by WCBA varied significantly, even within the eight-state region of the Great Lakes. Species like canned tuna made up a greater proportions of the meals consumed by women in Minnesota, whereas shellfish and haddock were more frequently consumed in New York.

Messages in fish consumption advisories should emphasize the health benefits and importance of fish consumption, encouraging consumption of low-contaminant species. Even though there was variation in species consumed within the Great Lakes region, the total amount of fish consumed did not vary. Average consumption was consistent at 0.93 meals/week across the region, much lower than federal advice for desired consumption. Some demographic sub-groups (older, more educated, non-White WCBA without children age 15 or younger living in the household) reported consuming more fish, patterns consistent with findings from previous research (e.g., EPA, 2013; Knobeloch et al., 2005; Lando et al., 2012; Traynor et al., 2013). Even among these sub-groups, however, our model estimated an average of 1.5 meals/week, a rate of fish consumption which is still lower than federal advice.

Although state fish consumption guidelines are often focused strongly on sport-caught fish from within-state, recommendations should be included regarding purchased fish, focusing on the health benefits of eating fish while affirming advice about species to avoid or limit. Among WCBA in our study, most of the fish consumed were purchased fish, not sport-caught fish. Several states do currently offer advice for purchased fish, and in some cases the advice is more detailed than the federal advice, including recommendations for fish with moderate mercury levels (e.g., MDH, n.d.).

Very few members of this audience exceeded the federal recommendations for consumption of canned “white” tuna (0%), or consumption of “do not eat” species (4%), similar to the findings of Lando et al. (2012) in a national study, and Silver et al. (2007) in a study of low income WCBA in the California Sacramento-San Joaquin Delta. We also found very few WCBA exceeding the recommended limit for total fish consumption (3-5%), similar to Lando et al. (2012). These findings suggest that at the broad population level there does not appear to be a need for greater attention to risk messages beyond reinforcing the guidance that already exists.

Messages about purchased and sport-caught fish should focus on eating a certain amount of fish to obtain the benefits from fish consumption for WCBA and their potential offspring. Very few women (10-12%) in our study were eating the recommended amount of fish averaged over the 16-week study period, with 84-87% eating less than the recommended amount. Mahaffey et al. (2009) came to a similar conclusion studying WCBA who lived in the same geographic area as our sample, but who did not necessarily fish. They found using data from the NHANES study

that WCBA ate on average less than 1 meal/week of fish. Using more recent NHANES data (2009-2010), the EPA (2013) reported that among those who ate fish, 60% of WCBA nationally ate less than 0.75 meals/week.

WCBA living in the Great Lakes region who were anglers were consuming more fish on average than national estimates for WCBA in the summer months when sport-caught fish consumption would be expected to be highest due to favorable conditions for fishing and increased recreational opportunities. The EPA (2013) reported average consumption for those who ate fish was 12.8 g/day, calculated from 2009-2010 data presented in the report, compared with our estimate of 18-20 g/day. However, this was still not enough fish for women to obtain all the health benefits for themselves and their potential offspring.

Enhanced outreach efforts appear to be necessary to focus on encouraging more WCBA to eat more low-risk fish. Other researchers have suggested this as well (Bloomingdale et al., 2010; Lando et al., 2012; MDH, 2012; Teisl et al., 2011). We recommend focusing future research on measuring actual behavior change among women of childbearing age exposed to different messages that encourage consumption of low-risk fish. WCBA are not eating enough fish to maximize the potential for health benefits, even among this group of anglers who may have the greatest opportunity and inclination to eat larger quantities of fish.

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SECTION 3: ARE WOMEN ANGLERS OF CHILDBEARING AGE IN THE GREAT LAKES REGION FOLLOWING FISH CONSUMPTION GUIDELINES?*

ABSTRACT: States in the Great Lakes region of the United States issue fish consumption guidelines for women of childbearing age (WCBA) to help them minimize the health risks to themselves and their potential offspring from eating fish contaminated with chemicals. We used diary methods to study 1,395 WCBA who purchased fishing licenses in the Great Lakes coastal region to determine if they were aware of the guidelines and following them. We found that two-thirds of WCBA reported at least minimal awareness of the fish consumption guidelines, and those that reported awareness were more likely to hold beliefs consistent with the messages emphasized in the guidelines. WCBA reported eating less than one meal/week of fish with most of this fish purchased at a store or restaurant. On average, they consumed just 2.4 sport-caught fish meals over the 16-week study period. The average portion size for sport-caught fish meals eaten by WCBA was similar to that assumed by states when determining the guidelines. However, one-quarter of WCBA in the overall sample exceeded the guidelines, with rates as high as 41% exceeding the guidelines in Michigan and Minnesota. Additional outreach efforts may be needed to increase compliance with fish consumption guidelines, particularly among subpopulations that exceed the guidelines more frequently.

KEYWORDS: anglers; fish consumption; fish consumption guidelines; Great Lakes; risk communication; women of childbearing age

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1. Introduction

Eating fish contaminated with chemicals like mercury and polychlorinated biphenyls (PCBs), poses health risks to women and their potential offspring (Jacobson and Woodson, 1993; Lonky et al., 1996). These risks may include carcinogenesis and developmental, reproductive, behavioral, metabolic, or neurological impairment (e.g., Counter and Buchanan, 2004; Davidson et al., 2004; Humphrey, 1988; Kreiss, 1985). Some of the chemicals of greatest concern in the Great Lakes region include methylmercury, PCBs, dioxin, and mirex. For example, a study in the late 1990s found that women who ate salmonines from Lake Ontario had higher concentrations of mirex in their breast milk than women who ate Lake Ontario panfish or did not eat Lake Ontario fish at all (Madden and Makarewicz, 1996).

As a result of these concerns about chemical contaminants, U.S. states have issued fish consumption guidelines for several decades. Most states target women of childbearing age (WCBA) and children 15 or younger with the most restrictive guidelines because of the concerns described above. Guidelines for WCBA in the Great Lakes region range from do-not-eat recommendations for species such as large carp or lake trout (Pennsylvania Department of Environmental Protection, 2016) to less restrictive guidelines (one or two times per week) for species such as sunfish or yellow perch, which are low in contaminants and can provide health benefits if consumed (Minnesota Department of Health, n.d.).

Past research has shown that most anglers are generally aware of the fish consumption guidelines in their state (Connelly et al., 1993; Imm et al, 2005; Katner et al., 2011; Kearney and Cole, 2003). For example, Connelly et al. (2012) found that over 90% of anglers living in the Great Lakes region were aware of sport-caught fish advisories. However, certain segments of the angler community (e.g., younger, non-white) were less likely to be aware (Katner et al. 2011).

Awareness of the advice for sport-caught and purchased fish among WCBA may be more variable, and in some cases lower, than awareness among anglers in general. Imm et al. (2005) found that while 65% of male Great Lakes anglers were aware of the advice for fish caught in the Great Lakes, only 30% of women were aware. Gliori et al. (2006) conducted a study of Wisconsin women who recently gave birth and found that 65% of those who ate sport-caught fish had some awareness of the Wisconsin advisory. However, only 3% said they knew a lot about the advisory. Connelly et al. (2014) found that two-thirds of new mothers surveyed in Minnesota, Wisconsin, and Pennsylvania who fished or had a household member that fished reported receiving information about the types of fish and how much fish to eat. Specifically for mercury, Lando et al. (2012) found that 73% of pregnant and 74% of postpartum women were aware that mercury was a problem, while Knobeloch et al. (2005) said few (20%) WCBA were aware that states issue guidelines about mercury consumption.

Several studies show that most anglers believe they are following the guidelines of their state (Imm et al., 2005; Kearney and Cole, 2003). However, other studies show that they may be mistaken. A recent study of urban anglers living in three areas within the Great Lakes region found that between 7% and 40% of anglers were exceeding the guidelines for the area where they lived (Lauber et al., 2017). In a 1992 survey of Lake Ontario anglers, 36% consumed fish in

excess of the fish consumption limits recommended for Lake Ontario, and of that group, 90% said they believed their consumption was within the recommended limit (Connelly et al., 1996). These studies focused on anglers in general, not WCBA specifically. Very little is known about the adherence of WCBA to the sport-fish guidelines specific to them. Silver et al. (2007) suggest that this may be because local advisories vary a great deal, and consequently, determining if they are being followed is a major challenge to researchers.

To address this gap, we conducted a study of women anglers of childbearing age living near the Great Lakes to determine if they were aware of fish consumption guidelines, where they reported getting their information, and if they followed the guidelines. We also explored whether notable socio-demographic groups within WCBA were more or less likely to exceed the guidelines.

2. Methods

We used a web-based diary method, described in detail in Connelly et al. (2016), to gather fish consumption data from WCBA who had fishing licenses and lived in U.S. counties bordering the Great Lakes. We drew a random sample of 15,000 fishing licenses sold over the previous year to women aged 18 to 48 (who would reach a maximum age of 50 [considered the end of the childbearing years] at the end of our two-year study[8]). We drew the sample by state in proportion to the number of licenses sold in each state to WCBA. We set recruitment quotas for each state based on the number of participants we estimated we needed at the end of the two-year study for sufficient power in our statistical analysis. The recruitment quotas were in the same proportions as the sample selection. We recruited participants by mail and telephone.

We collected fish consumption information from participants for 16 weeks from May 18 through September 6, 2014. For each meal reported, participants recorded whether the fish was purchased (at a store or restaurant) or sport-caught (i.e., fish caught by you or someone else), the species eaten, the portion size, and (for sport-caught fish) where the fish was caught. We provided a list of fish species, including the most commonly consumed purchased fish and those with consumption guideline recommendations, along with a text box to record purchased fish species not on the list. For sport-caught species, we listed only those with consumption guideline recommendations and provided an "other" option. Participants indicated portion size in reference to a picture of an 8 oz. uncooked (6 oz. cooked) portion of salmon (Fig. 1); we asked participants if the meal they ate was larger, smaller, or the same size as the picture.

We obtained data on participant age from fishing license records. We gathered data on awareness of fish consumption guidelines, sources of information, beliefs about fish consumption, pregnancy and breastfeeding status during the study period, and other socio-demographic characteristics, such as education, income and race, using online surveys conducted at the end of diary data collection.

[8] We report only data from the first year of the study in this paper, as the second year of data collection involved an experimental manipulation.

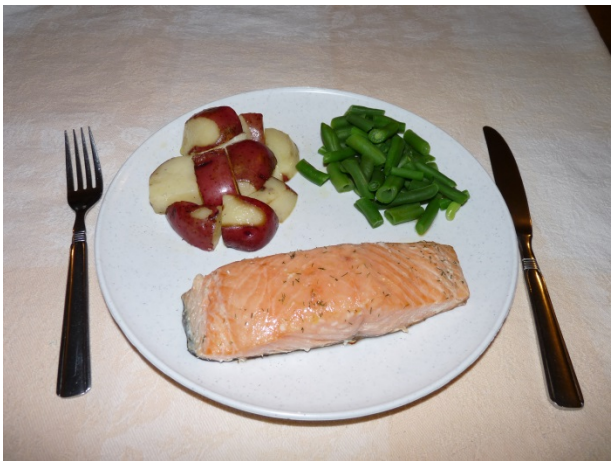

Fig. 1. Picture shows an 8 oz. uncooked (6 oz. cooked) portion of salmon.

We analyzed data from the diary using SPSS (IBM SPSS Statistics 24). We used chi-square tests to identify statistically significant differences between subgroups at the $P < 0.05$ level. Any differences described in the narrative text are statistically significant at this level.

We compared the meals eaten by each participant to the guidelines of the state where they lived. We characterized participants as adhering to the guidelines if they kept their total consumption for the 4-month study period within the recommendations for that time period. For example, if the recommendation was to consume no more than one serving of coho salmon per month from Lake Michigan, and a person consumed five servings of coho salmon during the 4-month study period, we concluded that she had exceeded the guidelines. We measured fish consumption against the guidelines for the Great Lakes (including bays, tributaries, and connecting waters as defined by each state), the statewide guidelines for all other sport-caught fish, and the state guidelines (or federal guidelines if no state guidelines existed) for purchased fish. If an individual exceeded any of these guidelines, we concluded that she "exceeded the guidelines." This term, referring to an individual who exceeded one or more the state or federal guidelines, is used throughout the remainder of the paper. In those instances when we are referring to only the Great Lakes guidelines, we state that explicitly.

We present some results as ranges because some advice is based on the length of the fish caught; if consumers did not know the length of the fish they ate, we estimated their adherence to the guidelines assuming both the most and least restrictive consumption recommendations for that species. Similarly, a few consumers did not know the species of fish they were eating, or more commonly, reported eating multiple species at one meal. In these cases, we estimated their adherence to the guidelines assuming both the most and least restrictive consumption recommendations for the water where the fish was caught.

We report state-specific data unweighted; we weighted all other reported data (aggregated across states) in proportion to the number of fishing licenses sold to WCBA in the counties bordering the Great Lakes in each state. Weighting factors ranged from 0.85 to 1.17.

3. Results and Discussion

3.1 Diary recruitment and participation rates

We recruited 2,014 WCBA licensed anglers to participate in the study. Our recruitment quotas, which were in proportion to the number of licenses sold in each state, were met in six of the eight states. The number recruited was 6% less than the recruitment quota in Michigan and 17% less in Ohio, but after weighting the data (as described in the Methods section) the overall results are representative of the number of WCBA anglers from each state. We conducted our study in English, finding during the recruitment process only 22 women who could not participate because they did not speak English.

Women who agreed to participate were slightly older (35.5) than other women in the sample pool (33.7, $p<0.001$). Eighty percent of WCBA participated in the first two-week period, while 1,419 (70%) participated throughout the 16-week study period. WCBA who indicated in the recruitment process that they never ate fish were ineligible for the study; however, a few eligible participants (n=24) reported that they did not consume any fish during the 16-week study period and were thus excluded from the analysis. There were no differences in fish consumption between those who participated fully and those who participated during only part of the study period for the periods when the two groups overlapped. WCBA who participated the entire 16 weeks were slightly younger than those who did not (35.7 vs. 36.9, $p=0.042$). Since there was no difference in fish consumption and the difference in age was small, we considered WCBA who participated throughout the 16-week period as similar to all women who participated in the study and report results for the 16-week group only (final analytic sample n=1,395)[9]. These women were slightly older than the other women in the original sample pool (35.6 vs. 33.8, $p<0.001$).

By design, women in our study ranged in age from 18 to 48. The average participant was 36 years old. Most were white (95%) and half (52%) reported they had a college degree. The median household income was in the $50,000 to $75,000 range. Eleven percent reported earning less than $25,000 per year, and 7% reported earning more than $150,000. Half of the participants (51%) reported having children 15 years of age or younger living in their household. Only 6% reported being pregnant or breastfeeding during the 16-week study period.

3.2 Awareness of fish consumption guidelines

Two-thirds of participants (66%) indicated they had heard about government agencies providing guidelines recommending how much of certain kinds of fish you should or should not eat. Older participants were more likely to have heard of these guidelines (70% of those aged 30+ vs. 55% of those aged 29 or less) as were those without children 15 or younger living with them (69% vs. 62% with children). Participants were more likely to be aware of the guidelines for sport-caught

[9] Appendix E provides detailed information by state or state groupings for all questions asked of WCBA in the surveys conducted at the end of Year 1 and Year 2. These include questions about socio-demographic characteristics, awareness of fish consumption guidelines, sources of information, beliefs about fish consumption, perceived changes in fish consumption behavior between Year 1 and Year 2, and awareness of the brochure sent between study years.

fish compared with purchased fish (54% vs. 36%). Nevertheless, very few women reported they were aware of the *specific* guidelines for either sport-caught (8%) or purchased fish (2%). These findings regarding the level of awareness among all participants and older participants are similar to other studies of WCBA over more than a decade (Anderson et al., 2004; Connelly et al., 2014; Gliori et al., 2006).

WCBA anglers reported the fishing regulations guide most frequently as a source of fish consumption guideline information (Table 1). It was considered very useful by almost half (45%) of its readers. No other source was used by > 20% of WCBA anglers. One-third of WCBA anglers who accessed posted warnings, healthcare providers, websites, and sportsman's shows/outdoor expos considered them very useful. Sixteen percent of women used health information brochures (often available in healthcare settings) as a source of information, 28% of whom found them to be very useful.

WCBA anglers who were aware of the guidelines were more likely to hold several beliefs that are often emphasized in guideline communication (Table 2). For example, state guidelines often emphasize that the benefits of fish consumption outweigh the risks if women eat fish low in mercury and other contaminants. WCBA anglers who were aware of the guidelines were more likely to agree with this statement than those not aware. Similarly, WCBA anglers who were aware of the guidelines were more likely than those who were unaware to: (a) agree that children and unborn babies' health can be harmed more from chemical contaminants in fish than an adult's health, and (b) disagree that health problems related to eating contaminated fish are largely short-term. Exposure to the guidelines thus appears to be associated with a variety of beliefs that accurately reflect facts and key messages about fish consumption.

Table 1
Information sources where WCBA saw fish consumption guidelines and their perceived usefulness.

	Percent	
Information sources	Seen	Source rated as very useful by those who saw it*
Fishing regulations guide	31.0	45.4
Friends or family	19.9	26.5
Websites	19.8	34.9
Health information brochures	15.9	27.7
Newspaper articles	14.7	19.5
TV or radio	14.0	21.4
Posted warnings at fishing locations	13.3	55.4
Healthcare providers	10.8	36.2
Sportsman's shows or outdoor expos	3.8	31.5
iPhone/Smartphone apps	2.9	17.3

*Other categories included "somewhat useful" and "not at all useful."

Table 2
Percent agreeing (or disagreeing) with beliefs emphasized in guidelines by awareness of the government guidelines.

Beliefs	Aware of government guidelines	Not aware of government guidelines
	Percent agreeing*	
Benefits outweigh risks if women eat fish low in mercury and other contaminants**	50.3	40.8
Children's health can be harmed more than adults' health by chemical contaminants in fish**	64.1	47.4
An unborn baby's health can be harmed more than its mother's health by chemical contaminants in the fish that the mother eats**	71.3	55.1
	Percent disagreeing*	
Any health problems from eating fish contaminated with chemicals are mainly short-term**	62.5	42.6

*Agreeing includes the categories "strongly agree" and "agree." Disagreeing includes the categories "strongly disagree" and "disagree."

**Statistically significant difference between those aware and not aware at $p = 0.05$ using chi-square test.

3.3 Fish consumption

Participants consumed an average of 14.7 fish meals over the 16-week study period (just < 1 meal/week)[10], which is more than the average for all WCBA including non-anglers living in the area (Mahaffey et al., 2009). The majority of fish meals were purchased at a store or restaurant (mean of 12.3 meals over 16 weeks). Almost half of study participants (47%), all of whom had purchased a fishing license and lived near the Great Lakes, did not eat any sport-caught fish (i.e., fish caught by the WCBA angler or someone they know) during the study period. The average WCBA angler in the sample consumed 2.4 sport-caught meals over the 16-week period; 4.5 sport-caught meals were consumed on average by those eating sport-caught fish.

Almost half (45%) of sport-caught fish meals eaten were similar in size to the picture shown in the diary (Fig. 1). The picture represents an 8 oz. uncooked (6 oz. cooked) portion which reflects a common size assumption used by the Great Lakes states when determining recommendations for fish consumption., Almost one-third of meals (31%) eaten by participants were smaller than the picture, suggesting that participants who ate this size meal may have been exposed to less

[10] Most WCBA (76%) ate their fish meals distributed over the 16-week study period, with no single period comprising 25% or more of their total consumption. Twenty-four percent ate 25% or more of their meals within a two-week period. These WCBA might represent a group who ate most of their fish while on vacation, thus concentrating their exposure to potential contaminants within a short period of time.

contaminants than assumed in the guidelines. However, 24% of meals were larger than the assumed size, suggesting increased potential for exposure. With the average meal size reported consumed by participants approximately equal to the assumed meal size used by states to calculate exposure levels, this study provides state agencies with some confirmation of the validity of their assumption, recognizing some WCBA eat above and some below this average. State agencies also consider body weight when calculating potential exposure levels, and determining recommendations for fish consumption. Generally, a weight of 150lbs. is assumed. We had no information about participants' weights, so could not test that assumption, nor the interaction of body weight and meal size on potential exposure.

3.4 Adherence to guidelines

We chose the time of year for our study when the most sport-caught fish are eaten, based on past research (Connelly et al., 1996; Murkin et al., 2003). Therefore, the percent exceeding the guidelines is likely greatest during this period, so our results may provide a measure of the maximum percent likely exceeding the guidelines throughout the year.

We found 25-28%[11] of women anglers of childbearing age living near the Great Lakes exceeded fish consumption guidelines in the summer of 2014[12]. The percent of participants exceeding the guidelines varied considerably by state (Table 3)[13]. Michigan and Minnesota had the greatest percentages exceeding the guidelines (34-41%); Illinois and Ohio the least (12-13%). These rates are similar to those found in a 1992 survey of Lake Ontario anglers (mostly men), which reported 36% of anglers consumed fish in excess of the fish consumption recommendations (Connelly et al., 1996). It appears fish consumption in excess of recommended guidelines continues to occur.

Older participants and those without children 15 or younger living in their household were more likely to exceed the guidelines (Table 4), even though these same subpopulations were more likely to be aware of consumption guidelines. Although few women indicated they were pregnant or breastfeeding during the summer of 2014, the women who were pregnant or breastfeeding were less likely to exceed the guidelines than women who were not. Pregnant and breastfeeding women are considered to be the potentially most at-risk group within WCBA due to the risk of exposure for the fetus or infant, so greater compliance with guidelines among this group is particularly noteworthy. Race (white, non-white), education level, and income were not significantly related to adherence to the guidelines.

Of particular interest to us was the subpopulation of women anglers of childbearing age who were exceeding the guidelines associated with Great Lakes fish, as these women lived close to the Great Lakes and were therefore most likely to report consuming Great Lakes fish. We found

[11] The range in the percentage exceeding the guidelines is due to the assumptions made about meals when it was not clear what guidelines should be followed because of lack of specific information regarding fish size or species (discussed in detail in the Methods section).
[12] Appendix D profiles WCBA who exceeded the guidelines.
[13] Appendix F identifies the types of fish most likely to cause exceedance.

12-14% of participants exceeded the guidelines associated with Great Lakes fish. The range was from 0% to 26%, depending on the state (Table 5).

Table 3
Percent of women anglers of childbearing age who exceed the fish consumption guidelines, by state* and region.

	Percent exceeding guidelines	
State	Least restrictive consumption recommendations**	Most restrictive consumption recommendations**
Illinois	13.2	13.2
Indiana	24.5	28.6
Michigan	34.4	41.5
Minnesota	34.8	40.6
New York	29.2	29.2
Ohio	12.0	12.7
Pennsylvania	34.8	34.8
Wisconsin	18.4	19.0
Great Lakes Region	**25.3**	**28.2**

*Statistically significant difference between states at p = 0.05, df=7 using chi-square test.
**When the species or length of fish caught was unknown, adherence to the guidelines was calculated assuming both the least and most restrictive consumption recommendations.

Table 4
Percent of women anglers of childbearing age who exceed the fish consumption guidelines by significant socio-demographic characteristics.

	Percent exceeding guidelines	
Socio-demographic characteristics	Least restrictive consumption recommendations*	Most restrictive consumption recommendations*
Age		
18-29	20.6**	24.0
30-39	28.3	31.1
40-49	26.0	28.7
Children aged 15 or younger living in the household		
No	29.1**	32.4**
Yes	22.6	25.4
Pregnant or breastfeeding during study period		
No	26.2**	29.0**
Yes	11.5	13.5

*When the species or length of fish caught was unknown, adherence to the guidelines was calculated assuming both the least and most restrictive consumption recommendations.
**Statistically significant difference between exceeding the guidelines versus not and categories within a socio-demographic characteristic at p = 0.05 using chi-square test.

Table 5
Percent of women anglers of childbearing age who exceed their state's Great Lakes fish consumption guidelines, by state* and region.

	Percent exceeding Great Lakes guidelines	
State	Least restrictive consumption recommendations**	Most restrictive consumption recommendations**
Illinois	2.8	2.8
Indiana	16.3	20.4
Michigan	21.9	25.7
Minnesota	0.0	1.4
New York	21.2	21.2
Ohio	1.4	1.4
Pennsylvania	21.7	21.7
Wisconsin	3.8	4.7
Great Lakes Region	**12.5**	**14.1**

*Statistically significant difference between states at p = 0.05, df=7 using chi-square test.
**When the species or length of fish caught was unknown, adherence to the guidelines was calculated assuming both the least and most restrictive consumption recommendations.

4. Conclusions and Recommendations

Many women anglers of childbearing age report at least some awareness of the fish consumption guidelines, but most indicate they are not aware of the specifics. Those that are aware are more likely to hold beliefs consistent with the messages emphasized in the guidelines. Past work has also reported little awareness of guideline specifics among WCBA (Gliori et al., 2006). However, the proportion of women anglers of childbearing age living in the Great Lakes region that exceed fish consumption guidelines was not previously known. We found that substantial proportions of WCBA anglers are exceeding the guidelines, with an average of 25-28%, but as high as 41% in some states surrounding the Great Lakes.

The extent of non-compliance suggests that more needs to be done to communicate fish consumption guidelines to WCBA licensed anglers. One approach would be to increase efforts to promote the sources of information most commonly accessed and found to be most useful by this audience. WCBA licensed anglers most frequently reported the fishing regulations guide as a valuable information source. Similar findings have been reported for angler audiences in general (Connelly and Knuth, 1993; Connelly et al., 2012). Other sources considered very useful by some licensed female anglers are currently used less frequently, but they may be able to reach some of the women that the fishing regulations guides are not reaching. These include (a) posted warnings, (b) healthcare providers, (c) websites, and (d) sportsman's shows/outdoor expos. Additional research may be needed to learn how to increase access to and use of these sources.

Another recommendation would be for more states to consider providing guidelines for consumption of purchased fish, as we found most of the fish consumed were purchased fish even among this audience of WCBA anglers. If states provided guidelines for purchased fish, it would

enable WCBA who fish to be able to consult just one source for integrated advice about both sport-caught and purchased fish.

Fish consumption guidelines should also consider the type of women who exceed the guidelines. We found that WCBA anglers who exceeded the guidelines were more likely to be older and not have children living at home. These two subpopulations were also more likely to be aware of the guidelines. Perhaps these women are interpreting the guidelines as more important to follow for "women of childbearing intent" and for "children." Since they are older and do not currently have children at home, they may feel the guidelines do not apply to them, so they are more likely to exceed them. If our interpretation of why these women are more likely to exceed the guidelines is correct, then messages about the guidelines may need to be revised so they are more relevant to these groups. Perhaps these women are not following the guidelines to the letter, but they are protecting their health well because they will not have any more children. Do the more restrictive guidelines really need to be applied to these women?

When identifying ways to better communicate fish consumption advice to WCBA, it is also important to consider that fish also provide important health benefits for WCBA. A recent study by Connelly et al. (2016) found that WCBA anglers in the Great Lakes coastal region generally did not consume enough fish to obtain the maximum health benefits for themselves and their potential offspring. This finding suggests that fish consumption guidelines must encourage consumption of "safer" fish to obtain the health benefits while also reducing consumption of "riskier" fish to minimize the negative impacts of chemical contaminants.

Fish consumption guidelines, if followed, hold significant potential to reduce exposure to harmful chemical contaminants found in some fish. Our estimate of the number of WCBA licensed anglers exceeding those guidelines suggests that a substantial number of women are potentially exposed to harmful levels of chemicals from fish in the Great Lakes region. This estimate does not, however, indicate the actual contaminant loads of WCBA. Future research could more precisely estimate contaminant loads in WCBA by linking data on the types of fish meals eaten (location caught, species eaten, and meal size) with estimates of the amount of contaminants in each type of meal from fish sampling data. Such an analysis could be used to compare the actual contaminant loads with the guideline recommendations.

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SECTION 4: EFFECTS OF A PERSONAL NARRATIVE IN MESSAGES DESIGNED TO PROMOTE HEALTHY FISH CONSUMPTION AMONG WOMEN OF CHILDBEARING AGE*

ABSTRACT: Women of childbearing age can attain health benefits of fish consumption while minimizing risks by following state and federal fish consumption guidelines, but many women avoid fish out of concerns about mercury exposure. This study tested the impact of brochures, informed by communication theory and research, to promote healthy fish consumption among licensed female anglers. We conducted a randomized, two-wave longitudinal experiment between May 2014 and September 2015 among 1,135 women ages 18 to 48 years (at baseline), drawn from a sample of licensed anglers in the Great Lakes region of the United States. We randomly assigned women to one of five groups, to either be sent one of four brochures in spring 2015 using a two (including a short personal narrative or not) by two (using certain or uncertain language) factorial design, or to a no-exposure control arm. Participants reported their fish consumption in summer 2014 and summer 2015 via an online diary. Exposure to brochure versions that included a short personal narrative helped move women whose baseline levels of fish consumption were furthest from federal recommendations closer to these guidelines; effects were clearest among women confirmed, by self-report or web tracking, to have seen the brochure. Narratives hold promise as a strategy to communicate effectively about the benefits of healthy fish consumption and risks of overconsumption among women of childbearing age, but widespread dissemination may be necessary to achieve these effects.

KEYWORDS: narratives, uncertainty, nutrition, health communication

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1. Introduction

Health communicators have long struggled with efforts to promote healthy dietary behavior. While there is evidence that communication campaigns that achieve high levels of exposure can influence dietary behavior (Snyder, 2007; Wakefield, Loken, & Hornik, 2010), many Americans are confused about various dietary recommendations and as a result have low levels of adherence to dietary guidelines (Cornish & Moraes, 2015; Nagler, 2014). Dietary guidelines change regularly and are often nuanced, complex, and subject to criticism in the news media (Ferdman, 2016; Goldberg, 1992). In fact, many Americans report frequent exposure to contradictory messages about health and nutrition in the media, which in turn is associated with confusion, doubt about health recommendations in general, and lower adherence to dietary guidelines (Lee, Nagler, & Wang, 2017; Nagler, 2014). The information environment poses serious challenges for effective communication about dietary guidelines.

In response, the current study tested the impact of including theory-informed message features (narratives and acknowledgement of scientific uncertainty) in messages designed to increase adherence to fish consumption guidelines promoting healthy fish consumption among licensed female anglers of childbearing age, a population at elevated risk for mercury exposure. Specifically, we tested the impact of including (a) a short, personal narrative (versus a non-narrative version), and (b) acknowledging scientific and outcome uncertainty about the risks and benefits of fish consumption (versus no acknowledgement), on changes in fish consumption across two summer seasons, encompassing a total of 16 months.

1.1 The context: fish consumption guidelines and dietary behavior

Fish consumption guidelines represent an interesting case study of the challenges and complexity associated with communicating dietary recommendations. Fish and other seafood are a good source of lean protein and a primary source of omega-3 fatty acids (omega-3s) (Nesheim & Yaktine, 2007). Omega-3s are particularly important for pregnant women and women who may become pregnant because they offer significant health benefits to both adults and the physical and cognitive development of a fetus (Domingo, 2016; Innis, 2008). Fish consumption is also a primary source of human exposure to the heavy metal methyl-mercury (hereafter "mercury"). Some fish, dependent on species, size and waterbody of origin, accumulate unsafe levels of mercury from the environment. Significant accumulation of mercury in a woman's body is particularly detrimental to the neurological development of a fetus (exposure is passed on from the mother in the womb) and can cause muscular, visual, and cardiovascular problems in adults (Diez, 2009; Karagas et al., 2012).

Considering the potential risks and benefits, the US Department of Agriculture (USDA) advised at the time of our study that "women who are pregnant or breastfeeding consume at least 8 and up to 12 ounces of a variety of seafood per week from choices lower in methylmercury" (USDA & DHHS, 2010). This corresponds to 1-2 fish-meals per week. The USEPA also recommended that pregnant women, those who may become pregnant, breastfeeding mothers, and young children eat "up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury" (USFDA, 2004). Many states also offer guidelines encouraging consumption of fish low in mercury (USEPA, 2011).

Despite these recommendations, most women of childbearing age (WCBA), and pregnant women in particular, eat less fish than is recommended by federal agencies (Connelly, Lauber, Niederdeppe, & Knuth, 2016; USEPA 2013). A recent national survey, for example, found that the typical WCBA consumed only 3.0oz/week of fish (about half of a standard-sized fish-meal); the median level of consumption for women who were pregnant was 1.8oz/week (Lando, Fein, & Choiniere, 2012). Both estimates, far below national guidelines, suggest missed opportunities for obtaining the health benefits of omega-3s and other nutrients found in fish.

The public information environment surrounding fish consumption appears to have played a significant role in shaping fish consumption behavior in the U.S. Fish consumption declined rapidly after a 2001 federal advisory emphasized harms of mercury exposure from eating fish on fetal development (Oken, Kleinman, Berland, Simon, Rich-Edwards, & Gillman, 2003). Messages emphasizing the harms of mercury exposure in the news media continue to far outnumber messages about the benefits of eating fish (Greiner, Smith, & Guallar, 2010), and most state fish consumption advisories emphasize potential risks over potential benefits (Turyk et al., 2012). Indeed, many WCBA and pregnant women avoid fish out of concerns about mercury exposure (Bloomingdale et al., 2010; Lando & Zhang, 2012).

Despite these concerns, WCBA and pregnant women can attain health benefits of eating fish while minimizing risks by eating fish that are low in mercury (like haddock, tilapia, and shellfish) and following fish consumption advisories by state and federal agencies for sport-caught and purchased fish (USDA & DHHS, 2010). Efforts to warn WCBA and pregnant women about the health risks of mercury exposure, however, appear to have overshadowed information about the health benefits of fish consumption (Lando et al. 2012).

1.2 Communication interventions to promote healthy fish consumption among WCBA

In response, researchers have developed and evaluated communication interventions to increase healthy fish consumption. Two interventions targeted pregnant women. Oken et al. (2013) offered pregnant women in the intervention groups an 8-page print brochure (along with wallet-sized summary cards) that described the beneficial effects of omega-3s during pregnancy, encouraged them to eat fish, recommended fish species with low levels of mercury, and identified fish species to avoid. For the next 12 weeks, these women received weekly follow-up emails that encouraged them to eat low-mercury fish 2 times per week and offered recipes to do so. The authors reported increased fish consumption and intake of omega-3s among US pregnant women, but no differences in mercury intake or biomarkers of mercury exposure. Bosaeus et al. (2015) evaluated a 4-month dietary counseling intervention among pregnant women in the United States. The intervention featured 3 in-person sessions (once each trimester) and 5 follow-up phone calls, each of which encouraged women to eat three fish-meals per week and offered specific guidelines on specific low-mercury fish species to eat. The authors reported increased consumption of fish and intake of omega-3s.

Other interventions promote fish consumption among WCBA or adults in general, as many pregnancies are unplanned and fish consumption offers health benefits to adults and their potential offspring (USFDA, 2004). One trial tested the effect of a 12-week intervention,

involving 9 contacts with Canadian women, to increase compliance with a Mediterranean diet (in which eating fish is a significant component). The intervention described the principles of the Mediterranean diet, offered a cooking lesson relevant to the diet, and provided tailored guidance for dietary change based on self-reported dietary patterns at baseline. Evaluators reported increased fish consumption and reduced cholesterol and body mass index (BMI) among intervention participants (Goulet, Lamarche, Nadeau, & Lemieux, 2003). A 1-month community intervention in Australia used various media (TV, radio, newspapers, online) and outreach to schools and health practitioners to promote fish consumption by emphasizing the unique health benefits of eating fish. These authors reported significant increases in fish sales within a month of the intervention (McManus et al. 2011). Another Australian study reported increased consumption of fatty fish among adult participants at 3-months (but not at later time points) in response to a 12-month dietary counselling intervention involving six 1-hour, individually tailored, in-person sessions and six 30-minute follow-up sessions emphasizing benefits of increased fish consumption (Neale, Cossey, Probst, Batterham, & Tapsell, 2012).

Collectively, these studies show the potential for effective communication to promote healthy fish consumption among WCBA without increasing mercury exposure. However, each of the larger-scale intervention studies was resource intensive and thus may not be scalable given the typically limited resources available to government agencies tasked with providing fish consumption guidelines in the US. In addition, several of these studies occurred outside of the US, contexts where the public information environment about the relative risks and benefits of eating fish may differ (Greiner et al., 2010). None of these interventions made explicit use of, or reference to, behavioral or communication theory. As such, these studies do not provide guidance for health communicators on how best to convey information to maximize the effectiveness of efforts to promote healthy fish consumption.

1.3 Rationale for using narratives and acknowledging uncertainty in messages

In response to these gaps, the current study tested the impact of a short brochure designed to promote healthy fish consumption among licensed WCBA anglers in the Great Lakes coastal region of the US. We examined the impact of two features, informed by communication theory and research, that evidence suggests could strengthen guideline compliance that state and federal agencies may consider in the design of such messages: (a) personal narratives to supplement traditional risk/benefit information about fish consumption, and (b) acknowledging uncertainty in describing the risks/benefits of consuming fish.

1.3.1 Evidence for the value of narratives

Narratives are stories that feature one or more characters and describe events that take place over time and convey cause-and-effect relationships (Dahlstrom, 2014). Several meta-analyses and systematic reviews conclude that narratives can influence health-related attitudes and intentions (Braddock & Dillard, 2016; de Graaf, Sanders, & Hoeken, 2016) and often outperform other forms of evidence or argument in promoting these outcomes (Shen, Sheer, & Li, 2015; Zebregs, van den Putte, Neijens, & de Graaf, 2015). While narratives come in various forms, even very short personal stories can influence health-related attitudes and behavioral intentions (e.g.,

Niederdeppe, Heley, & Barry, 2015; Zebregs et al., 2015). There are a variety of potential explanations for why narratives may be particularly persuasive. For example, narratives can transport readers into the story world and in doing so reduce the tendency to counterargue the intended persuasive theme (Green & Brock, 2000). Narratives also invite readers to identify and empathize with focal characters, both of which increase the likelihood of persuasion (Tal-Or & Cohen, 2010). There is general agreement that stories are more engaging, memorable, and concrete than other forms of evidence or argument (Dahlstrom, 2014).

1.3.2 Limitations in the evidence base

Despite rapid growth in the evidence base over the past two decades (author own cite), very few studies have documented narrative effects on changes in health behavior. A meta-analysis by Braddock and Dillard (2016) and a systematic review by De Graaf et al. (2015) identified only a handful of studies testing narrative effects on behavior (5 out of 74 total experimental studies in Braddock and Dillard (2016) which compared narrative messages to true control conditions; 5 of 153 experimental or quasi-experimental studies in de Graaf et al. (2015) which reviewed quasi- or true- experiments in which researchers exposed participants to a narrative and subsequently gauged their impact on health-related beliefs, attitudes, intentions and/or behaviors), limiting the conclusions that can be drawn about their potential to shape dietary behaviors like fish consumption. It is also unknown whether a short narrative embedded within a larger set of messages describing complex and lengthy dietary guidelines, like those recommendations offered for fish consumption, can influence behavior over time.

1.3.3 Narrative hypotheses

Nevertheless, in light of prior research documenting narrative effects on attitudes and behavioral intentions, we hypothesized that exposure to a brochure that included the narrative message would increase healthier fish consumption relative to a no-exposure control group (H1) and a non-narrative version of the brochure (H2). We defined healthy fish consumption as either (a) increasing consumption of fish low in mercury among women consuming below state and federally recommended guidelines at baseline, and/or (b) reducing consumption of fish among women consuming above recommended guidelines.

1.3.4 Evidence and arguments for the value of acknowledging uncertainty

Evidence on the impact of uncertain versus certain language in describing risk and benefit information has been the subject of considerable recent debate (e.g., McCormack et al., 2013; Committee on Decision Making under Uncertainty (CDMU), 2013). Many authors suggest that fish consumption guidelines should be as clear and simple as possible (e.g., Oken et al. 2012). Accumulating evidence suggests, however, that the use of hedged language (using language like "may" or "can" to qualify or soften causal claims; Lakoff, 1972) versus more definitive language (e.g., "will, does") may be beneficial in conveying risk and benefit information (Jensen, 2008; Mayweg-Paus & Jucks, 2015). While the mechanisms behind these effects are not yet clear, these authors speculate that using hedged language to acknowledge scientific uncertainty may enhance trust and facilitate deeper processing and acceptance of the message (Jensen, 2008; Mayweg-Paus & Jucks, 2015). We further suggest that explicit acknowledgement of the

probabilistic nature of causal claims in environmental health science may help reduce the tendency to use examples in counterargument to risk or benefit assessments (e.g., "my mom ate tuna every day when pregnant and I turned out just fine") by acknowledging variability in outcomes associated with fish consumption behaviors.

1.3.5 Limitations of the evidence base

Researchers have noted the need for more evidence on how best to communicate information laden with various forms of uncertainty, including deficits in the evidence base (scientific uncertainty) and the probabilistic nature of causality (outcome uncertainty) (Bier 2001; CDMU 2013; Han 2013). In fact, several federal agencies explicitly note the need for research on how best to communicate information laden with various forms of uncertainty (McCormack et al., 2013; CDMU, 2013).

1.3.6 Uncertainty hypotheses

In light of the arguments described above, we hypothesized that exposure to a brochure acknowledging scientific and outcome uncertainty in describing the health risks and benefits of eating fish would increase healthier fish consumption relative to a no-exposure control group (H3) and a more certain version of the brochure (H4).

2. Methods

2.1 Study design overview

We conducted a randomized, two-wave longitudinal experiment, involving 1,135 WCBA drawn from a sample of licensed anglers, between May 18th, 2014 and September 5th, 2015. Participants reported their fish consumption in summer 2014 by completing an online diary for recording fish-meals, receiving a reminder every two weeks. We then randomly assigned women to one of five groups, to either be sent one of four brochures in spring 2015 using a 2 (including a short personal narrative or not) by 2 (certain or uncertain language) factorial design, or to a control arm which did not receive any version of the brochure. All WCBA participants completed a fish consumption diary again in summer 2015. Cornell University's Institutional Review Board for Human Subjects reviewed all procedures involving human subjects and considered the study exempt from broader review.

2.2 Sampling strategy

We drew a sample of 15,000 fishing licenses sold to women ages 18 to 48 that lived in counties bordering one of the Great Lakes in the US. We drew the sample by state, in proportion to the number of licenses sold in each state to women who lived in counties bordering the Great Lakes. We sent invitation letters to each member of the sample in February 2014, offering up to $45 for participation in the project (depending on compliance and rates of completion) and providing a link to a sign-up page on the Internet. The sign-up page described the study in detail and asked respondents for their informed consent to participate. We provided a postage-paid return postcard for people to opt out of the study because they did not eat fish, did not have regular

Internet access, or were not interested in participating. We sent a follow-up letter to all invitees a week later encouraging participation.

We made telephone calls to encourage sign-up directly over the telephone among those who did not sign-up or return a postcard. We obtained and verified email addresses and then used email for all communication with study participants.

Initially, 2,014 WCBA provided informed consent to participate. Of these, 1,395 provided information for the entire 16-week study period in Year 1 (69% of those who consented). 1,135 of these women also provided information for the entire 16-week study period in Year 2 (56% of those who originally consented). There were no differences in demographics or fish consumption between those who participated for the entire 16-week period in Year 1 and those who only participated in some weeks during Year 1. Thus we report results only for women who provided complete data in Years 1 and 2 (N = 1,135).

2.3 Dependent variables: Fish consumption reported via online diaries

We collected fish consumption information for 16 weeks from mid-May through mid-September 2014 and again over the same four-month period in 2015. We gave each participant a link unique to her to access her personal fish consumption diary on the Internet. We incentivized them to complete the diary at least every two weeks with $2 per fortnight. The diary first asked women to report on any meals in which they consumed fish. For each meal reported, participants recorded whether the fish was purchased (at a store or restaurant) or sport-caught (i.e., fish caught by you or someone else) and the species eaten. We obtained data on participant age from fishing license records. We gathered data on other demographics in an online survey at the end of Year 1 (N = 1,081) and data on brochure recall in an online survey at the end of Year 2 (N = 946).

We calculated several dependent variables to gauge changes in fish consumption based on diary reports. We calculated the total number of fish-meals consumed in summers 2014 (m = 14.6, SD = 10.0) and 2015 (m = 13.5, SD = 9.6). We also calculated the total number of purchased (p) and sport-caught (sc) fish-meals consumed in summers 2014 (mp = 12.0, SDp = 9.6; msc = 2.6, SDsc = 4.2) and 2015 (mp = 11.4, SDp = 9.3; msc = 2.1, SDsc = 3.7). Most fish-meals were of purchased fish (82% in summer 2014; 85% in 2015). Finally, we calculated the number of lower-mercury purchased (lmp) fish-meals (including all purchased shellfish, salmon, cod, tilapia, fish sticks/fast food sandwiches, haddock, and farm-raised catfish) and all other purchased/all sport-caught (opsc) fish-meals consumed in summers 2014 (mlmp = 7.5, SDlmp = 7.1; mopsc = 7.1, SDopsc = 6.4) and 2015 (mlmp = 7.2, SDlmp = 7.1; mopsc = 6.3, SDopsc = 5.8).

2.4 Independent variables: Versions of the fish consumption guidelines brochure

We developed four versions of a fish consumption guideline brochure based on a review of existing literature, formative message testing via short pilot surveys of the target population (drawn from a different sampling frame than the main study; N = 601 women of childbearing age), and a series of five focus groups (range of 4 to 11 participants per focus group). We used the pilot surveys to assess closed-ended responses (agreement with the message; perceived argument strength) to a series of candidate messages about the risks and benefits of fish

consumption and selected highly rated statements for use in the final page of the brochure. We used the focus groups to gauge responses to three different narratives and chose the version that focus group participants received most favorably. We worked closely with public health, pollution control and natural resource agency representatives from the eight Great Lakes States to develop brochure content that (a) was consistent with state-specific advice and (b) agency officials thought had the potential to be incorporated into existing health communication practices related to fish consumption among WCBA.

A professional graphic artist arranged and formatted content for all of the brochures. Each brochure followed the same general orientation and flow. The front page, entitled, "Your guide to eating fish and shellfish," featured a series of photographs and a short message emphasizing the benefits of fish consumption using either certain or more uncertain terms ("Fish [is/can be] an important part of a healthy diet for all women. It [is/may be] even more important for women who are pregnant, breastfeeding, or might become pregnant"). The second page featured either a short personal narrative or a series of responses to frequently asked questions. The third page (and in some cases on an additional two-sided page if the state had extensive fish consumption guidelines) featured state-specific fish consumption guidelines that matched Great Lakes and statewide guidelines for sport-caught and, in states where they are offered, purchased fish. These guidelines spanned several pages and detailed fish consumption guidelines for specific species and sizes of fish found within a particular state, as well as fish from particular waterbodies known to have fish with high levels of contaminants. For states that do not offer purchased fish advice, we used federal guidelines (current at the time) from the USEPA and USFDA (USFDA, 2004). The final page featured a series of facts on fish, first emphasizing the benefits of fish consumption ("Fish is low in calories, has plenty of protein, and is a great way to get omega-3s. Eating fish [lowers/may lower] the risk of heart disease and other health problems") but also offering advice on ways to maximize health benefits while minimizing risks ("most fish are a healthy food, but eating some types of fish [raises/may raise] health risks over time").

2.4.1 Narrative versus FAQ

The narrative version featured a short, personal story about a young woman who was trying to become pregnant and was surprised to learn that fish can be an important part of a healthy diet for women in general but also before, during, and after pregnancy. The narrative conveyed three central messages – that (1) fish are a great source of omega-3s, (2) some types of fish have more chemical contaminants than others, and (3) fish consumption guidelines can help her to choose which fish are healthier to eat and which to try to avoid. The FAQ version conveyed the same messages using identical language to the extent possible (see Figures 1 and 2). The FAQ section was (on average, depending on state-specific details) 140 words, while the narrative section was longer (averaging 220 words) due to the need to include details about the character, setting, and storyline. The overall brochure ranged from 595 to 1,615 words (depending on the extent of advice given by a state), so the narrative and FAQ sections represent a relatively small part of the brochure's overall content.

Figure 1. Narrative version of the brochure.

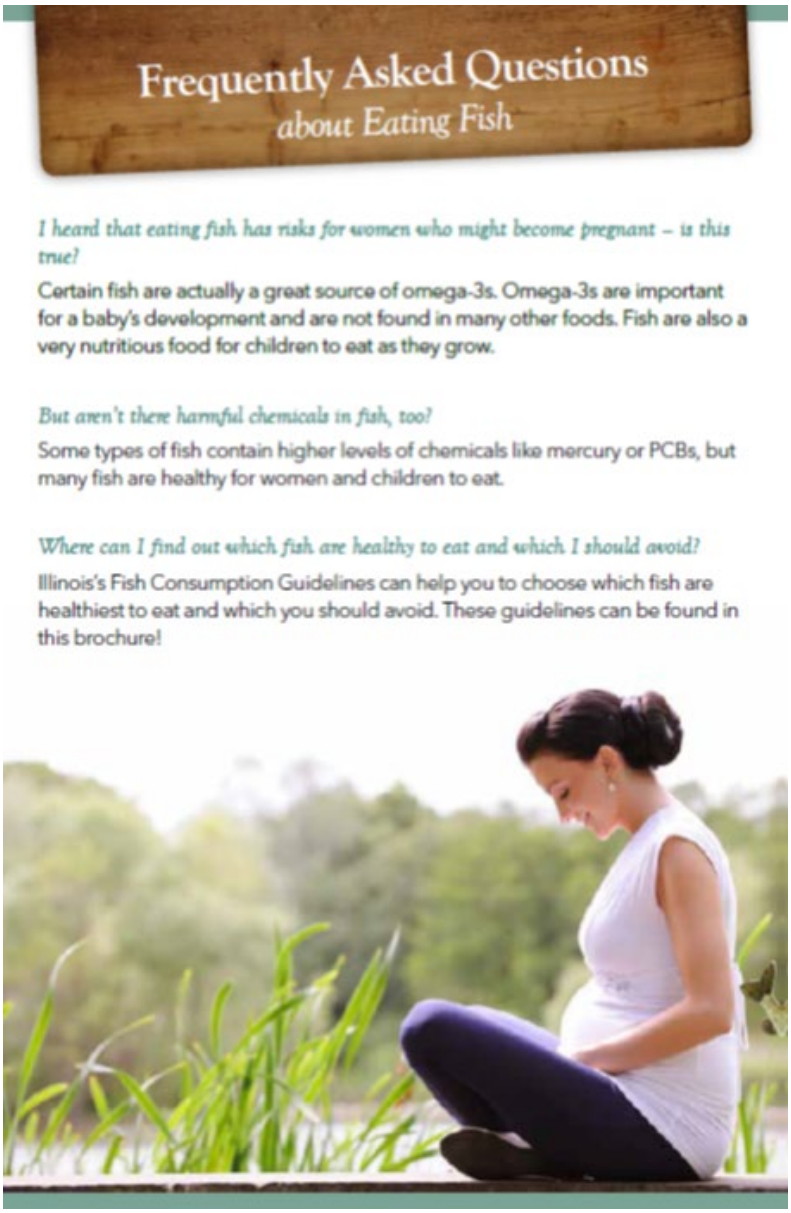

Figure 2. Frequently asked questions (FAQ) version of the brochure.

2.4.2 Uncertain versus certain

The uncertain version differed from the certain version in the degree to which we described relationships between fish consumption and health benefits and risks as hedged ["may cause, can be, might"] or definitive ["causes, is, will"]. We manipulated this language throughout the first (title), second (narrative or FAQ), and final (facts on fish) pages of the brochure in every instance where we described potential health benefits and/or risks of fish consumption. In addition, the uncertain language version included an extra statement on the final page, among the other facts on fish, calling attention to the probabilistic nature of health causation: "It is difficult to know who might have health problems from chemicals in fish. Some people can be fine after years of eating fish with these chemicals in them, while others can have health problems."

We mailed brochures to participants randomly assigned to one of the four (non-control) experimental groups about one week before data collection began in Year 2. We also provided a link to the brochure at the top of the first page of the fish consumption diary. We used web-tracking software to record each time a participant clicked on the brochure link.

2.5 Analytic approach

A priori planned analyses. We used chi-square and t-tests to assess whether random assignment produced balanced groups on measured variables across the five experimental conditions (using $p < 0.05$ as the statistical criterion throughout). We used paired-sample t-tests to compare the number of fish-meals consumed in summer 2015 (follow-up) to summer 2014 (baseline). We used ordinary least squares (OLS) regression to test whether changes in fish consumption from baseline to follow-up were conditional on baseline consumption.

We used a series of OLS regression models to test whether assignment to a brochure featuring a narrative (H1-H2) or using uncertain language (H3-H4) influenced changes in fish consumption. The goal of these models was to identify whether the narrative and uncertain language versions of the brochure produced movement toward healthier fish consumption. The direction of desired movement toward healthier fish consumption (eating between 1-2 fish-meals per week of fish lower in mercury) depended on a woman's baseline level of fish consumption. Specifically, we sought to increase healthy fish consumption among those women who were not consuming fish-meals within these guidelines, and to decrease fish consumption among those women who consumed more than recommended. We used interaction terms between baseline levels of fish consumption and randomized condition (e.g., narrative versus control; narrative versus FAQ) to test whether narrative and uncertain conditions would have different effects depending on levels of fish consumption at baseline.

To test H1, we included five variables: a continuous variable indicating the number of fish-meals consumed in summer 2014, an indicator for the narrative condition, an indicator for the uncertain language condition, an indicator for the FAQ/certain condition, and an interaction term between baseline levels of fish consumption and an indicator for the narrative condition. We needed the indicator for the FAQ/certain condition to make the "reference" group for each dummy variable the no-exposure control group, providing information relevant to H1. We repeated these analyses for each dependent variable: overall number of fish-meals consumed, number of purchased fish-

meals consumed, number of sport-caught meals consumed, and number of purchased, low-mercury meals consumed. In support of H1, we expected to see a statistically significant interaction term between baseline levels of fish consumption and the narrative condition. When statistically significant, we probed these interactions using the Johnson-Neyman technique to identify levels of the moderator (baseline fish consumption) at which effects of the dependent variable (e.g., brochures with a narrative vs. FAQ) were statistically significant (see Hayes, 2013). Probing the interactions in this way provided evidence central to H1 – whether the narrative increased healthy fish consumption among those with low baseline levels of consumption and/or deceased consumption among those with baseline levels above guideline recommendations.

We repeated these basic analyses with small changes to provide information relevant to H2 through H4. To test H2, we replaced the indicator variable for the FAQ/certain condition with an indicator variable for the control group, permitting us to test whether the effect of the narrative condition differed from the FAQ condition. To test H3, we replicated models used to test H1 but substituted the narrative*baseline fish consumption interaction term with a new variable that interacted baseline levels of fish consumption with an indicator of the uncertain condition. To test H4, we replaced the indicator variable for the FAQ/certain condition with an indicator variable for the control group, permitting us to test whether the effect of the uncertain condition differed from the certain condition.

We ran preliminary models in which we controlled for respondent demographics and state of residence; the inclusion of these controls did not influence the magnitude or significance of our tests of study hypotheses, so we do not include them in the models presented in text or tables. We also ran models in which we interacted indicators for whether or not respondents were assigned to the narrative versus FAQ and whether they were assigned to view certain versus uncertain language to test for possible (but not hypothesized) interactions between narrativity and uncertain language. None of these interactions were statistically significant (all Ps > .05) so we do not report on them in the text or tables.

Post hoc analysis conditional on confirmed exposure to the brochure. There was limited evidence of brochure exposure among WCBA in groups to which we sent it. Among those who completed the end of year survey (N = 946 total) and were randomly assigned to be sent the brochure (N = 628), only 63% (N = 397) recalled receiving it in the mail. Far fewer (17%; N = 104) recalled looking at it online. 472 respondents (75%) recalled viewing the brochure in either the mail or online. Among these, the majority (60%) reported looking at it just once, when they first received it. Most of the rest (37%) reported looking at it only "a few times." Web tracking data confirmed these reports of low exposure – only 20% of those randomly assigned to view it clicked on the brochure, and the vast majority of these respondents (81%) clicked on it only once. Combining all of these confirmed types of exposure, we calculate that 67% (N = 525) of respondents randomly assigned to receive the brochure had at least one indicator (recall or web tracking) of confirmed exposure.

We used this information to create a "confirmed exposure plus control" (CEC) subgroup comprised of these 525 respondents (considered exposed to the brochure in all analyses using

this subsample) and the 365 respondents from the control group who provided complete data in Years 1 and 2 (considered unexposed to the brochure in this subsample). We repeated all multivariable regression analyses with two different samples: one involving all study respondents (overall N = 1,135) and the other involving the CEC subgroup (N = 890).

3. Results

3.1 Participant demographics, randomization and manipulation checks

The average participant was 36 years old in Year 1 (Table 1). Most were white (95%), half (54%) reported earning a college degree, and nearly half (45%) reported a household income between $50,000 and $99,999 before taxes in 2014. Only 85 women were pregnant or breastfeeding during the study period; we were thus unable to analyze this group separately. Among those randomly assigned to receive the brochure, respondent demographics were similar between those with or without confirmed exposure, with one exception: those with confirmed exposure were more educated than those without confirmed exposure ($p < .05$).

There were no statistically significant differences in demographic composition (on measured variables) or baseline fish consumption between the five randomized groups in either the overall sample or the CEC subgroup (all ps > .05). This indicates that we can still interpret any differences in response to the various brochure conditions as a causal influence of exposure to those stimuli, as brochure exposure was not confounded with demographics.

We included one item on the end of study survey designed to serve as a manipulation check for whether or not respondents noticed the certain versus uncertain language (there was no manipulation check for the narrative versus FAQ version). Specifically, we gauged agreement with the statement, “Some people will have health problems from eating fish contaminated with chemicals, while others won’t,” a statement only included in versions of the brochure with uncertain language. Respondents assigned to the uncertain language brochure were more likely than those assigned to the certain language brochure to agree (standardized B = .08, p = .023), providing evidence that the manipulation was successful.

3.2 Changes in fish-meals consumed over time

More than half of the WCBA in the sample reported eating less than 1 fish-meal per week at baseline in summer 2014 (62%) and summer 2015 (67%) (these percentages were not statistically different; $p > .05$). A small percentage of WCBA in the sample reported eating greater than 2 fish-meals per week in summer 2014 (5%) and this percentage remained similar at follow-up (4% in summer 2015; these were not statistically different, $p > .05$).

Table 1
Sample characteristics of the overall sample and those randomly assigned to be sent the brochure, with and without confirmed exposure.

Demographic Characteristics	**Overall Sample**	**Randomly Assigned to be Sent the Brochure, <u>with</u> Confirmed Exposure**	**Randomly Assigned to be Sent the Brochure, <u>without</u> Confirmed Exposure**	***X*² or t, *p*-value[a]**
Age [mean (SD)]	36.2 (8.3)	36.2 (8.3)	36.3 (8.1)	T(1)=0.18, *p* =.86
Non-white [N (%)]	53 (4.9)	27 (5.3)	15 (7.3)	X^2(1)=0.99, *p* =.32
Education [N (%)]				X^2(2)=7.22, *p* =.03
High school or less	85 (7.9)	40 (8.0)	23 (11.3)	
Some college or technical school	407 (38.0)	175 (35.0)	87 (42.6)	
College grad or more	580 (54.1)	285 (57.0)	94 (46.1)	
Household income before taxes in 2014 [N (%)]				X^2(2)=1.13, *p* =.57
Less than $50,000	275 (29.8)	136 (29.1)	41 (33.1)	
$50,000 to $99,999	420 (45.4)	120 (47.0)	58 (46.8)	
$100,000 or more	229 (24.8)	112 (23.9)	25 (20.2)	

Note: Percentages in columns reflect valid percentages among those who provided an answer within each demographic category. [a] Statistical tests compare those randomly assigned to brochure exposure groups (a) who were confirmed to have clicked on the brochure or who recalled receiving the experimental brochure, versus (b) those who did not click and did not recall receiving it.

Overall, WCBA in the sample consumed fewer fish-meals in summer 2015 (M = 13.5, SD = 9.6; 0.84 meals/week) than in summer 2014 (M = 14.6, SD = 9.9; 0.91 meals/week; t-score for mean difference from zero = -5.4, $p < .001$). These patterns were similar for the CEC subgroup (mean difference = -.9, t-score for difference from zero = -3.7, $p < .001$). These changes were dependent, however, on baseline levels of fish consumption. The number of fish-meals consumed in summer 2014 was a significant ($p < .001$) predictor of change (in both the overall and CEC samples) in fish-meals from baseline to follow-up. We used this model to predict the direction and magnitude of change at various levels of baseline fish consumption. For WCBA with no baseline fish consumption in summer 2014, the overall model estimates an increase of 2.75 fish-meals from baseline to follow-up. The model further estimates that each 1-unit change in fish-meals at baseline reduced the predicted change in consumption by 0.26 fish-meals. Combining these coefficients, the model estimates that WCBA who ate up to 10 fish-meals in summer 2014 tended to increase fish consumption in summer 2015. In contrast, the model estimates that WCBA who ate 11 or more meals in summer 2014 tended to reduce fish consumption the next summer. The size of this reduction became larger as baseline levels of fish consumption increased. We observed a similar pattern of change for purchased meals, lower mercury fish-meals, and sport-caught fish-meals.

3.3 Predicting changes in fish-meals consumed by exposure to the narrative version

We next ran a series of OLS regression models predicting changes in overall, purchased, sport-caught, lower-mercury purchased and other (other purchased plus all sport-caught) fish consumption as a function of baseline fish consumption, brochure condition (narrative, uncertain language, and the FAQ w/certain language), and the interaction between the narrative condition and baseline fish consumption. These models revealed a consistent pattern of significant interactions between baseline fish consumption and the narrative brochure version in predicting overall, purchased, sport-caught, and lower-mercury purchased fish consumption in 3 of 4 models with the overall sample ($ps < .05$; Table 2) and 4 of 4 models with the CEC subgroup (all $ps < .01$; Table 3). The models showed statistically significant differences of nearly identical magnitude relative to both the control group (shown in tables; consistent with H1) and those exposed to the FAQ brochure version (not shown in tables; consistent with H2).

We probed interactions within the CEC subgroup (where effects were clearest) to identify levels of baseline consumption at which effects of the narrative brochure were statistically significant. The narrative brochure significantly ($p < .05$) increased overall fish consumption, relative to control or FAQ, for WCBA who ate 11 or fewer fish at baseline (0.7 meals per week, a level below recommendations yet consumed by 44% of the sample). The magnitude of these effects ranged from an increase of 1 fish meal for women who ate 11 fish-meals at baseline to 2.4 total fish-meals among women who ate no fish at baseline. The narrative brochure also reduced overall fish consumption for WCBA who ate 46 or more fish-meals at baseline (2.8 per week, a level above recommendations but consumed by only 1% of the sample). The effect was estimated to reflect a reduction of 3.0 total fish-meals for women who ate 46 fish-meals at baseline (Figure 3).

Table 2
OLS regression models predicting fish-meals consumed relative to the no-exposure control group in summer 2015, overall sample (N = 1,135).

	Overall [Coefficient (SE)]	Purchased [Coefficient (SE)]	Sport-Caught [Coefficient (SE)]	Lower Mercury [Coefficient (SE)]
No-Exposure Control	Ref.	Ref.	Ref.	Ref.
# of fish-meals, summer 2014	0.76*** (0.02)	0.78*** (0.02)	0.73*** (0.02)	0.77*** (0.02)
Narrative	1.01 (0.71)	0.44* (0.62)	0.10 (0.17)	0.49 (0.44)
# of fish-meals in 2014*narrative	─0.06 (0.04)	─0.08* (0.04)	─0.12** (0.04)	─0.09* (0.04)
Uncertain	─0.09 (0.42)	─0.06 (0.40)	─0.02 (0.15)	0.17 (0.32)
FAQ w/certain language	─0.87 (0.54)	─0.70 (0.52)	─0.16 (0.19)	─0.28 (0.41)
Constant	2.58*** (0.44)	2.12*** (0.39)	0.30** (0.12)	1.48*** (0.29)
Model R-Squared	0.58	0.59	0.65	0.56

Notes: OLS, ordinary least squares. Ref, referent category in linear regression model. FAQ, frequently asked questions. * $p < .05$; ** $p < .01$; *** $p < .001$.

Table 3
OLS regression models predicting fish-meals consumed relative to the no-exposure control group in summer 2015, CEC subgroup sample (N = 890).

	Overall [Coefficient (SE)]	Purchased [Coefficient (SE)]	Sport-Caught [Coefficient (SE)]	Lower Mercury [Coefficient (SE)]
No-Exposure Control	Ref.	Ref.	Ref.	Ref.
# of fish-meals, summer 2014	0.77*** (0.03)	0.80*** (0.03)	0.73*** (0.02)	0.81*** (0.03)
Narrative	2.39** (0.85)	2.60*** (0.73)	0.20 (0.20)	1.27* (0.52)
# of fish-meals in 2014*narrative	─0.12* (0.05)	─0.15*** (0.05)	─0.14** (0.04)	─0.15** (0.05)
Uncertain	0.22 (0.50)	0.29 (0.48)	─0.03 (0.18)	─0.57 (0.38)
FAQ w/certain language	─0.32 (0.65)	─0.31 (0.63)	─0.03 (0.23)	0.21 (0.49)
Constant	2.34*** (0.49)	1.87*** (0.43)	0.28* (0.12)	1.21*** (0.31)
Model R-Squared	0.57	0.59	0.63	0.56

Notes: OLS, ordinary least squares. CEC, confirmed exposure + control subgroup. Ref, referent category in linear regression model. FAQ, frequently asked questions. * p <.05; ** p <.01; *** p <.001.

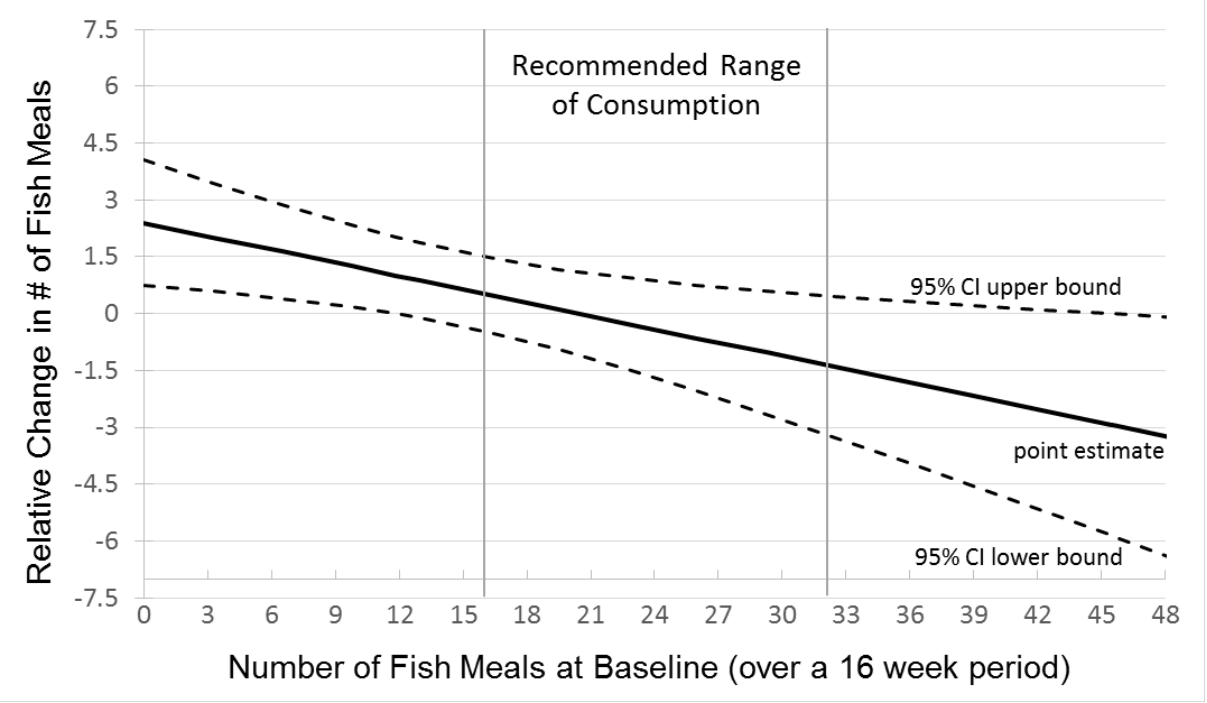

Figure 3. Model predicted change in fish consumption, narrative version versus control group, CEC subgroup sample (N = 890).

Patterns were similar for purchased and lower mercury fish-meals. The narrative brochure significantly increased purchased fish consumption (relative to control or FAQ) among women with 11 or fewer baseline purchased fish-meals (56% of the sample) and reduced purchased fish consumption among women with 29 or more baseline purchased fish-meals (6% of the sample). The narrative brochure also significantly increased lower mercury fish consumption (relative to control or FAQ) among women with 2.5 or fewer baseline lower mercury fish-meals (24% of the sample) and reduced lower mercury fish consumption among women with 14.5 or more lower mercury fish-meals at baseline (12% of the sample). The pattern was somewhat different for sport-caught fish-meals. The narrative brochure significantly decreased sport-caught fish consumption among WCBA with 3.4 or more purchased fish-meals (24% of the sample) by a magnitude ranging from a decrease of 0.3 fish-meals (at 3.5 sport-caught fish-meals at baseline) to 0.7 sport-caught fish-meals (at 7 sport-caught fish-meals at baseline, the 90th percentile). Combined, these models offer strong and consistent evidence that the inclusion of a short, personal narrative in brochures presenting information about the risks and benefits of fish consumption for WCBA produced changes toward healthier fish consumption relative to the control group (supporting H1) and the group receiving the brochure that featured FAQs instead of a narrative (supporting H2).

3.4 Predicting changes in fish-meals consumed by exposure to the uncertain version

We also ran a series of OLS regression models predicting changes in overall, purchased, sport-caught, lower-mercury purchased and other (other purchased plus all sport-caught) fish

consumption as a function of baseline fish consumption, brochure condition (narrative, uncertain language, and the FAQ w/certain language), and the interaction between the uncertain condition and baseline fish consumption in predicting fish consumption at follow-up. None of the interaction terms between baseline fish consumption and the uncertain brochure version were statistically significant in predicting overall, purchased, sport-caught, and lower-mercury purchased fish consumption in: (a) the overall sample using the control group as the reference category, (b) the overall sample using the FAQ/certain group as the reference category, (c) the CEC subgroup using the control group as the reference category, or (d) the CEC subgroup using the FAQ/certain group as the reference category (all ps > .05; not shown in tables). Combined, these models offer no evidence that acknowledging scientific or outcome uncertainty produced changes toward healthier fish consumption among any WCBA in the study relative to either the control group (rejecting H3) or the brochure that did not acknowledge scientific and outcome uncertainty (rejecting H4).

4. Discussion

4.1 Summary of findings

This study provides evidence that WCBA who were (a) furthest from federal recommendations for levels of fish consumption at baseline and (b) exposed to a brochure featuring a short personal story about the benefits of eating fish were more likely to move toward recommended levels of fish consumption at follow-up than WCBA randomized to either the no-exposure control group or FAQ brochure versions. These effects were evident among both women with baseline fish consumption below recommended levels (for whom healthier fish consumption entailed increases in consumption of fish low in mercury) and women with baseline levels of fish consumption above federal recommendations (for whom healthier fish consumption entailed decreases in fish consumption).

Effects were clearest among WCBA with evidence of confirmed exposure to the brochure. Among WCBA with low baseline fish consumption (≤ 11 fish-meals over the 16-week baseline period), those with confirmed exposure to the narrative version of the brochure increased their fish consumption by 1-2 fish-meals more than women exposed to FAQ versions of the brochure or randomized to the control condition. In contrast, among WCBA with high baseline levels of fish consumption (≥ 46 fish-meals over the 16-week baseline period), those with confirmed exposure to the narrative brochure version decreased their fish consumption by 3-5 fish-meals more than women exposed to non-narrative versions of the brochure or women randomized to the control condition. Changes in purchased fish consumption appeared to drive these changes. The narrative brochure also reduced sport-caught fish consumption among periodic to regular consumers of these meals, a generally favorable outcome since some sport-caught fish from the Great Lakes region tend to have high levels of mercury and other contaminants. The use of certain versus uncertain language in the brochures had no effect on fish consumption among WCBA in either the overall study sample or within the CEC subgroup.

4.2 Implications for health communication research and practice

Our findings provide evidence that narratives hold promise as a strategy to help in effectively conveying information about the benefits of modest fish consumption and the risks of fish overconsumption among WCBA to women who are the least inclined to eat at levels consistent with federal recommendations. We interpret these findings as offering initial, behavioral evidence for the benefit of including short, personal narratives in fish consumption recommendations, as opposed to a specific prescription for how health communicators should implement and disseminate such a strategy in the longer term.

We say this for two reasons. First, while a majority of WCBA randomly assigned to be sent the brochure reported looking at it, most women who saw it reported looking at it only one time. Health campaign research emphasizes the importance of high levels of exposure repeated over an extended period for sustained behavior change (Wakefield et al., 2010), suggesting a missed opportunity for the current intervention to have had a larger effect on behavior. Second, and likely related to the level of exposure, the magnitude of message effects was quite modest, ranging from 1 to 5 fish-meals over a 16-week timeframe during which 16 to 32 meals of lower-mercury fish would be recommended. These effects are smaller than other, larger-scale fish consumption interventions have achieved in other contexts (e.g., Bosaeus et al., 2015; Goulet et al., 2003; McManus et al. 2011; Neale et al., 2012; Oken et al., 2013), albeit likely at a fraction of the cost.

Despite modest levels of exposure and effect sizes, we nevertheless argue that these findings are noteworthy for health communication research and practice. A small-scale intervention (a single brochure largely seen only once) featuring a single, short personal narrative (comprising only a quarter of the broader brochure) produced consist patterns of evidence consistent with a effect on behavior change (across four different outcome measures, which suggests that these findings are unlikely a product of chance alone). In light of this evidence, we thus argue that these findings suggest meaningful opportunities for health communicators to convey both the benefits and risks of fish consumption. Adding a short, personal narrative to existing fish consumption advice appears to be a cost-effective way to increase the potential impact of that advice on fish consumption among WCBA. The fact that we observed such strong and consistent patterns of narrative effects in both the overall and CEC subgroup sample is particularly noteworthy in this context. However, it also suggests that other dissemination methods may be more impactful. Future work should test strategies to achieve greater distribution and more widespread and frequent exposure.

We found no evidence that the use of uncertain language made a difference in shaping fish consumption behavior over the course of the study. Here we offer a few speculative ideas on why this may have been the case. First, it may be that the hedging language manipulation and/or the probabilistic nature of causality manipulation were too subtle and limited to make a difference. Both of these manipulations were much shorter than the narrative (in terms of the number of words); we did not have a manipulation check to test whether respondents noticed a difference in the use of hedging words, and the observed difference in the belief that effects of mercury exposure are probabilistic was very modest in magnitude. Stronger manipulations may

be necessary for uncertain language to have an effect on behavior. Second, it may be that our outcome measures (number of fish-meals consumed in various categories) were not sensitive to the type of effects that these messages may have had on mercury intake. While we tried to categorize fish-meals in broad terms by their mercury content (e.g., lower-mercury fish), these measures are blunt indicators of the actual level of mercury that women consuming various species would be exposed to. Some women may have continued to eat fish at the same rate while switching to lower-mercury alternatives.

More nuanced information about the average level of mercury exposure in each fish-meal might reveal subtler changes in fish consumption patterns in response to the uncertain language conditions. Future research should explore these possibilities in detail.

4.3 Contributions to the literature on narrative persuasion in health communication

This study offers new evidence that narratives can contribute to changes in dietary behavior over time. As noted in both a recent systematic review and meta-analysis, very few studies have tested for narrative effects on behavioral outcomes (Braddock and Dillard, 2016; de Graaf et al., 2015). Our use of a two-wave, 16-month longitudinal design allowed us to detect small but significant differences in fish consumption behavior in response to fish consumption guideline brochures that featured a short, personal narrative. This study thus deepens the body of knowledge on persuasive effects of health-related narratives, offering new evidence about conditions under which previously documented effects on attitudes and intentions may translate into longer-term behavior change.

The current study also opens up new avenues for narrative persuasion research in demonstrating that very short, personal narratives can help to convey complex and nuanced information subsequently offered in non-narrative formats. The fact that exposure to the narrative version of the brochure was associated with both increased fish consumption among WCBA with low-levels of baseline fish consumption (the desired outcome for increasing omega-3 intake) and decreased fish consumption among WCBA with high baseline consumption levels (also the desired outcome) suggests that the narrative enhanced the delivery of complex information. The short narrative alone did not provide sufficient detail to permit a WCBA to identify specific species of low-mercury fish or convey the specific consumption guidelines (1 to 2 fish-meals per week); it (indirectly) referenced the more-detailed guidelines that appeared later in the brochure. This suggests that the narrative version of the brochure may have worked by enhancing attention to or motivation to comply with the subsequent information. Previous work has largely explored the impact of narratives, in and of themselves, in shifting attitudes and intentions (e.g., Dahlstrom, Niederdeppe, Gao, & Zhu, 2017) or moving toward more complex understanding of health issues (e.g., Niederdeppe, Shapiro, Kim, Bartolo, & Porticella, 2014). Future theory and research should explore the ways that narratives may enhance (or possibly detract) attention from other non-narrative forms of information relevant to behavioral decisions.

4.4 Study limitations

Several limitations are worth noting. As described above, the study's mode of dissemination did not generate high levels of confirmed exposure. Those seeking to promote fish consumption

among WCBA may require different channels of distribution or more frequent points of contact to promote larger increases in healthy fish consumption.

We did not design the intervention to be a test of the most effective mode of fish consumption guideline dissemination and so it is not directly comparable to the ways that states typically deliver guideline information. It is possible that regression to the mean partially accounts for observed increases in fish consumption among those with lower levels of consumption at baseline and declines among those with higher consumption levels. Regression to the mean would not, however, explain why exposure to the narrative version of the brochure produced greater changes than in other conditions.

The design of our study also precluded tests of mechanisms that might explain the narrative condition effects on fish consumption. We delivered the brochures both electronically and by mail in May 2015, but respondents did not complete the follow-up survey (aside from reporting their fish consumption behavior via the diary) until September 2015. We deemed this too long of a period for meaningful measurement of narrative mechanisms like transportation, counterarguing, identification, and/or empathy. Most narrative persuasion studies conducted to date have been single-session experiments or studies with a short period of follow-up. These design characteristics are very helpful for gauging narrative mechanisms but limited in their ability to test for behavioral effects over time. The current study was able to provide evidence of behavior change but sacrificed the ability to understand the mechanisms behind these behavioral effects.

We included a single item in the post-study survey to test whether the uncertainty manipulation was successful. That item only asked about one aspect of the manipulation (the probabilistic nature of causality) and likely failed to capture whether respondents were aware of the hedged language aspect of the manipulation. It is possible that respondents did not notice the hedging manipulation, which could explain why we failed to detect any effects of uncertain language on behavior.

All WCBA in the study indicated that they eat fish at least sometimes and were licensed anglers in the Great Lakes coastal region, so findings may not apply to the broader population of WCBA in general. While WCBA are an important target for fish consumption guidelines because many pregnancies are unplanned, we did not ask whether participants planned to become pregnant in the future. Information on the risks and benefits of fish consumption may have been particularly salient for women planning to have a child. The sample included very few WCBA who were pregnant or breastfeeding; we cannot speak to these populations.

4.5 Conclusion

Effectively conveying dietary guidelines present difficult challenges for health communicators. We provide evidence that narratives hold promise as a strategy to communicate effectively about the benefits of healthy fish consumption and risks of overconsumption among licensed angler women of childbearing age, a group at elevated risk for exposure to contaminants in fish. Acknowledging scientific and outcome uncertainty associated with the risks and benefits of eating fish does not appear to influence the frequency of fish consumption among this group.

Widespread dissemination to ensure high levels of message exposure may be necessary to offset messages emphasizing risks of fish consumption that appear to be widely available in the larger information environment.

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SECTION 5: URBAN ANGLERS' ADHERENCE TO FISH CONSUMPTION ADVISORIES IN THE GREAT LAKES REGION*

ABSTRACT: Urban anglers are considered a group at high risk of being exposed to contaminants from fish consumption. Past studies of urban anglers' fish consumption, however, have had significant limitations making it difficult to generalize their findings broadly and to assess the degree to which urban anglers are complying with advisory recommendations. We used a diary method to collect detailed information on fish consumption in three cities in the Great Lakes region for a 4-month period during the summer of 2014. We assessed how much fish anglers were consuming, whether they were complying with fish consumption advisories, and how fish consumption and advisory compliance varied for different demographic groups and in different locations. We estimated a mean of 1.12 meals/week of fish and 25.1-26.8 g/day of fish, and the amount of fish consumed varied by no > 25% from one site to another. Advisory exceedance was more variable, however, ranging from 7-10% to 27-40% in our three study sites. Fish consumption increased with age, education, and income, and was higher for nonwhites than for whites. Advisory exceedance was higher for women, nonwhites, and older anglers. At each site, the types of fish that contributed the most to advisory exceedance varied, which points to the benefits of community-specific (and resource-intensive) fish consumption advisories. Our findings could help fish consumption advisory programs tailor their advice to vulnerable populations and particular locations.

KEYWORDS: fish consumption, advisories, urban anglers

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1. Introduction

The Great Lakes Restoration Initiative Action Plan II identifies urban anglers as a group at high risk of being exposed to contaminants through fish consumption (Great Lakes Interagency Task Force, 2014). Although eating fish provides a variety of health benefits, urban waters in industrialized areas may be polluted, and some types of fish in those waters accumulate high levels of industrial contaminants (Burger et al. 1999). Eating contaminated fish is associated with higher body burdens of contaminants such as PCBs and mirex (Bloom et al. 2005, Knobeloch et al. 2009). Therefore, fish consumption advisories have been promulgated for many waters, and the advisories for urban waters are sometimes more restrictive than advisories for other waters. Urban anglers are considered more likely than other anglers to fish at urban sites and, if they eat the fish they catch, more likely to be exposed to the contaminants in these fish.

Past work on urban anglers has explored the demographic characteristics of urban anglers (Burger et al., 1999; Lauber et al., 2017), fish consumption by demographic groups that are more prevalent in urban areas, such as low income individuals, racial minorities, and immigrant groups (Burger et al., 1999; Silver et al., 2007; West et al., 1993), and how urban anglers make decisions about fish consumption and use fish advisories (Beehler et al., 2003, 2001; Burger et al., 1993; Lauber et al., 2017; Pflugh et al., 1999). Relatively little work, however, has investigated the fish consumption patterns and adherence to advisories of urban anglers themselves. The limited work that has been done on this topic provides some insight into how much fish urban anglers are eating and which types of people are eating more. Overall, this work finds considerable variation in the volume of sport-caught and purchased fish consumption as well as the potential for exposure to contaminants through excessive consumption beyond that which health authorities advise.

Some of this work has explored fish consumption by urban ethnic populations that were expected to eat a lot of fish. Hutchison and Kraft (Hutchison and Kraft, 1994) studied sportfish consumption in the Hmong community of Green Bay, Wisconsin, in 1989 and 1990. They interviewed 125 Hmong households to collect information on the types of fish people reported catching and how frequently they ate fish they caught over the course of a year. They reported that 61% ate sportfish once a month or less and only 9% ate sportfish at least once a week. They calculated an average of 30 sportfish meals for each household over the course of a year, which was considerably higher than the rate of fish consumption among Wisconsin anglers overall. Their conclusion was that some members of the Hmong community were likely eating sportfish in excess of fish advisory recommendations, but they did not quantify advisory adherence.

Murkin et al. (2003) documented patterns of fish consumption among frequent fish consumers in five Ontario Great Lakes Areas of Concern (sites with significant impairment of beneficial uses) between 1995 and 1997. They targeted two groups of people they considered at risk of eating too much contaminated fish: Asian-born anglers (identified through key informants, social and religious community organizations, newspapers, and health fairs) and anglers observed to be fishing at selected shore fishing sites (a group that has been a common focus in urban angler studies). Through home visits with 91 participants, they collected data on quantity and type of fish consumed during each season over the previous twelve months. They reported means of 33 meals of Great Lakes fish over the summer, 99 sportfish meals each year, and 157 total fish

meals each year. Asian-born anglers consumed more fish than European- Canadian- or United States-born anglers. Considerable variation existed in the types and parts of fish that were eaten.

Burger (2002) reported fish consumption patterns of anglers fishing in the urban Newark Bay complex of New York and New Jersey. She interviewed 267 people fishing on site between May and September 1999. She reported 4.06 meals (1410 g) of fish/month for anglers who only fished and 3.56 meals (1630 g) of fish/month for anglers who both fished and crabbed. Consumption increased with age, and nonwhites were more likely to eat their catch.

Sheaffer and O'Leary (2005) collected data on fish consumption through an onsite survey of 946 anglers who were fishing in metropolitan areas of Indiana in the spring and summer and compared it with similar data collected for 1,743 licensed Indiana anglers collected through a statewide mail survey. The data were collected in 1997 and 1998. The mail survey asked anglers to report their consumption over the past three months, and it was administered to different samples of anglers at three different times of the year to obtain better estimates of annual fish consumption. They found slightly higher consumption of sportfish in the metropolitan anglers compared to the statewide sample (22.9 vs. 19.8 g/day) with 18% of the metropolitan anglers eating in excess of advisory limits compared to 16% of the statewide sample. Nonwhite anglers in the metropolitan areas consumed more fish than white anglers.

Kearney and Cole (2003) reported on fish consumption of 232 licensed anglers in two Ontario cities in 1992. The sample was selected to represent anglers who ate a lot of Great Lakes fish. Anglers were asked to recall the numbers and species of Great Lakes fish consumed over a 12-month period, reporting the results by season whenever that was possible. The authors found differences in the amount and species of fish eaten in the two communities, with reported fish consumption ranging from 10.9-34.2 meals/year and 12.3-19.9 g/day. Sportfish consumption was not related to age or income. In one of the communities, anglers with the lowest levels of education ate more fish.

Lauber et al. (2017) characterized the fish consumption of anglers who self-identified as being from urban areas in a mail survey of licensed anglers from the Great Lakes region of the United States. They reported means of 5.4 sportfish meals/year (with 63% eating at least some sportfish) and 12.5 purchased fish meals/year (with 70% eating at least some purchased fish). Fish consumption increased with income. Their study was the only one of this set that selected a representative sample of anglers living in urban areas. The others all selected samples of anglers that were expected to consume a lot of fish because of their ethnicity, fishing locations, or the results of a screening process.

These studies have some significant limitations. The narrow definition of study populations as well as the approach to sampling in some studies would make it difficult to generalize to larger populations. Most sample sizes were relatively small, making it difficult to compare subpopulations within groups. Many of the studies only considered sportfish consumption, although consumption of purchased fish can also contribute to risk. Most of these studies report on data collected in the 1990s or earlier and are now dated. Finally, participants in the studies were asked to report fish consumption by recalling either how much fish they typically ate or

based on their recall of a specific 3- to 12-month period; these methods of reporting are likely to be less accurate than more proximal recollections (e.g., in the past few weeks).

In addition, only one of these studies reported whether fish consumption complied with fish consumption advisory recommendations. Federal, state, and tribal agencies provide advisories for fish consumers on the amounts and types of fish they can safely consume based on analyses of contaminants in fish and different waters. With sufficient data on fish consumption, noncompliance with advisories can serve as an indicator of excessive exposure to contaminants in fish. Although advisory compliance is not a measure of contaminant exposure, it is indicative of whether state and federal agencies consider likely levels of contaminant exposure (based on estimates obtained by sampling of contaminants from fish in various waterbodies) to be within safe limits. Studies measuring advisory compliance, therefore, can contribute to risk management decisions.

This study seeks to complement previous studies by reporting on urban anglers' fish consumption and compliance with fish advisories based on data collected from 1,200 anglers in 3 metropolitan areas in the Great Lakes region of the United States in the summer of 2014. We selected a representative sample of licensed urban anglers, which allows us to explore how vulnerable subpopulations are similar to or different from the larger population of anglers living in cities. We used a diary method, in which anglers reported fish consumed on at least a biweekly basis, to assess the amounts and types (species, lengths, and location caught) of fish consumed over a 4-month period. These detailed data on fish consumption enable us to assess advisory compliance. We report on anglers' adherence to fish consumption advisories in each area and how fish consumption and advisory compliance varied with demographic characteristics.

2. Methods

2.1 Study sites

We selected three urban counties in the Great Lakes region as our study sites: the counties containing Kalamazoo, MI, Erie, PA, and Rochester, NY. Each of these cities had populations of at least 75,000 people. All 3 sites had statewide sportfish advisories as well as advisories for local bodies of water (with advice for particular species and lengths of fish), but the complexity of these advisories varied. In Rochester and Erie, only one to three local bodies of water had special advisories, but 11 local bodies of water had special advisories in Kalamazoo. Michigan is also the only state of the three that publishes advice for the consumption of purchased fish.

2.2 Sample selection and diary recruitment

We drew a sample of 15,000 fishing licenses sold to licensed anglers who lived in one of three study sites; we drew 5,000 licenses for each site. We sent invitation letters to each member of the sample in February 2014. The letter described the study and what would be required of participants. It also offered a financial incentive of up to $20 for participation in the project and provided a link to a sign-up page on the Internet. We provided a postage-paid return postcard for people to opt out of the study because they did not eat fish, did not have regular Internet access, or were not interested in participating. We sent a follow-up letter to all invitees a week later encouraging participation.

We called those who did not sign-up or return a postcard to encourage participation and allow them to sign up over the telephone. Calling ceased when at least 2,000 total participants and at least 600 participants in each city had been reached. During the study sign-up process, we obtained email addresses and then checked them by sending out a study participation verification email. We then used email for all communication with study participants.

2.3 Diary data collection

We collected fish consumption information for 16 weeks from May 18 through September 6, 2014. Participants recorded data in two-week blocks. Participants could record information as many times as they wished during the two-week period. Every two weeks we sent an email invitation to participants to signal the start of the next two-week period and remind them that the previous two week-period was ending. When a two-week period ended, we sent up to three reminders to participants who had not completed entering data for the period to finish recording their information for the period. Participants earned financial incentives for each period completed and received a bonus at the end if they completed reporting for every period.

We gave each participant a link unique to them to access their personal fish consumption diary on the Internet. On the initial page, participants saw information for the eight two-week periods of the study, showing completed periods and incentives earned. On the next page we asked participants to record whether or not they ate fish on each day in the current two-week period. For each day they indicated they ate fish, another page opened asking the number of fish meals they had eaten on that day. For each meal reported, participants recorded whether the fish was purchased (at a store or restaurant) or sport-caught (i.e., fish caught by you or someone else), the species eaten, the portion size, and (for sport-caught fish) where the fish was caught. We provided a list of water bodies in each urban area that had special advisories for the fish caught there. We provided a list of fish species, including the most commonly consumed purchased fish and those with consumption recommendations, along with a text box to record species not on the list. For sport-caught species, we listed only those with consumption recommendations and provided an "other" option. Participants indicated portion size in reference to a picture of a 6 oz. cooked (170 g) portion of salmon (Figure 1); we asked participants if the meal they ate was larger, smaller, or the same size as the picture.

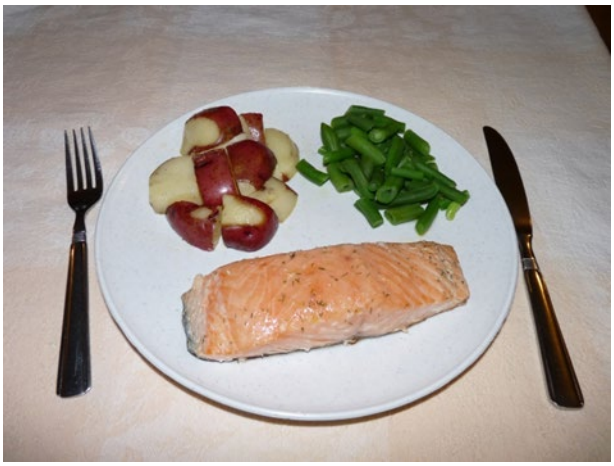

Fig. 1. Picture shows a 6 oz. piece of cooked salmon (8 oz. pre-cooked) provided to survey participants as a guide to estimating the amount of fish eaten at a meal.

We obtained data on participant age from fishing license records. We gathered data on other socio-demographic characteristics, such as education and race, using an online survey conducted during the last 2-week period of diary data collection.

2.4 Data analysis

Several previous studies have estimated the size of fish portions that people eat using pictures similar to those used in our study (Connelly et al., 1996; West et al., 1993) or plastic models (Silver et al., 2007). Since we provided a picture of a 6 oz. cooked salmon meal, we assumed those indicating an equivalent portion to the photo ate a 6 oz. portion (170 g). For 41% of meals, the participants indicated their portion size was smaller than the picture; we assumed that meant 4 oz. (113 g). For meals reported as being larger than the picture (19% of meals), we used a sensitivity analysis to compare two options for calculating portion size. For one option, we estimated the larger portion size to be 8 oz. (227 g) and for the other we assumed the size to be 10 oz. (283 g). We used these estimates to convert from the number and size of meals to an estimate of ounces and grams consumed per week or per day.

We analyzed data from the diary using IBM SPSS Statistics 20. We used chi-square tests to identify statistically significant differences between cities at the $P < 0.05$ level. Any differences described in the narrative text are statistically significant at this level. We used Scheffe's test to identify differences in portion sizes based on species of fish consumed. We used ANOVAs and chi-square tests to explain differences in fish consumption based on available demographic data.

We compared the sport-caught and purchased fish meals eaten by each participant to the recommendations of the state where they lived. Michigan provides advice for the consumption of both sport-caught and purchased fish, but New York and Pennsylvania only provide advice for sport-caught fish. Consequently, for those participants living in New York and Pennsylvania, we used the state advisories for sport-caught fish consumption and the U.S. EPA and FDA joint advice for purchased fish consumption. At the time of our study, the U.S EPA and FDA advice for purchased fish consumption was for women of childbearing age to: (a) eat no > 12 oz. of fish/week; (b) eat no > 6 oz. of albacore tuna/week; and (c) do not eat swordfish, shark, tilefish, or king mackerel.

We characterized participants as adhering to the advisories if they kept their total consumption for the 4-month study period within the recommendations for that time period. For each respondent, we added the total number of sport-caught fish consumed (of all species and from all locations) in each consumption category (1 meal/month, 1 meal/week, etc.). If a respondent's consumption of fish in any of those categories exceeded the consumption level for that category when averaged over the summer, we designated them as having exceeded the sport-caught portion of the advisory. For example, if the recommendation was to consume no more than one lake trout per month and one white perch per month from Lake Ontario, and a person consumed three lake trout and two white perch (i.e. total number of five meals for these species) during the 4-month study period, we concluded that he or she had exceeded the advisory recommendations (total of four meals for species in the 1 meal/month category for the study period). We measured fish consumption against the recommendations for local bodies of water and the statewide recommendations for all other sportfish. For purchased fish, we measured consumption against

the state recommendations (or federal recommendations if no state recommendations existed). If an individual exceeded any of these advisory recommendations for sport-caught or purchased fish, we concluded that he or she exceeded the advisories.

We present estimates of advisory exceedance as ranges because some advice is based on the length of the fish caught; if consumers did not know the length of the fish they ate, we estimated their adherence to the guidelines assuming both the most and least restrictive consumption recommendations for that species. Similarly, a few consumers did not know the species of fish they were eating, or more commonly, reported eating multiple species at one meal. In these cases, we estimated their adherence to the guidelines assuming both the most and least restrictive consumption recommendations for the water where the fish was caught.

We estimated the degree to which advisory exceedance was affected by the consumption of particular species of fish, consumption of fish from particular water bodies, and the consumption of too much low-mercury purchased fish (defined as purchased fish with recommended consumption limits of one/week or two/week). To estimate the contribution of particular species of fish to advisory exceedance, we eliminated the consumption data from each species of fish in turn, recalculated advisory exceedance, and calculated the percentage reduction in advisory exceedance. For example, to get an estimate of how much walleye consumption contributed to advisory exceedance, we calculated advisory exceedance without any data on walleye consumption. We used a similar approach to estimate the degree to which consumption of fish from particular local water bodies contributed to advisory exceedance. For some individuals, advisory exceedance was not caused by the consumption of particular contaminated fish, but by consumption of too much low-mercury purchased fish. To estimate the degree to which consumption of too much low-mercury purchased fish contributed to advisory exceedance, for all species of purchased fish which had recommended consumption limits of one/week or two/week, we assumed that no one exceeded these particular limits and recalculated advisory exceedance.

3. Results

3.1 Diary recruitment and participation rates

We recruited 2,099 study-eligible licensed urban anglers to participate in the study. Anglers who agreed to participate were slightly older (47.6) than other anglers in the sample pool (45.5, $p<0.001$). Seventy-six percent of urban anglers (n=1,587) participated in the first two-week period, while a smaller subset of 1,378 (66%) participated throughout the 16-week study period. Urban anglers who indicated in the screening interview that they never ate fish were ineligible for the study; however, a few eligible participants (n=15) reported that they did not consume any fish during the 16-week study period and were thus excluded from the analysis. There were no differences in fish consumption between those who participated fully and those who participated during only part of the study period for the periods when the two groups overlapped. Anglers who participated the entire 16 weeks were slightly older than those who did not (49.0 vs. 46.1, $p=0.005$), but their gender did not differ. Since there was no difference in fish consumption or gender and the difference in age was small, for simplicity we considered anglers who participated throughout the 16-week period as similar to all urban anglers who participated in the study and report results for the 16-week group only (final analytic sample n=1,363).

3.2 Angler characteristics

Between 400 and 500 anglers in each of the study sites completed the diaries throughout the summer of 2014[14]. The characteristics of the participants were fairly similar in all three sites (Table 1). They were predominantly white (92-95%) and male (82-84%). The mean age ranged between 45 and 52 years with Erie anglers significantly younger. The median household income level was in the $75,000-$99,999 range at all three sites. The most substantial difference between sites was in level of education. Sixty-two percent of participants in Kalamazoo had a college degree while only 46% of those in Erie did; Rochester anglers were in the middle at 53%.

Nonwhite anglers included Black or African American (42%), Asian or Pacific Islander (23%), Native American or Indian (11%), and Other (25%). Because of the small sample size for every racial category except White, we compared white and nonwhite anglers in our analyses.

Table 1

Characteristics of diary participants.

	Kalamazoo, MI	Erie, PA	Rochester, NY
Sample Size	414	449	500
Age (mean)	51.8	45.9	49.4
Gender – % male	82	84	82
Annual Household Income (median)	$75,000-$99,999	$75,000-$99,999	$75,000-$99,999
Education – % w/ college degree	62	46	53
Race – % white	95	95	92

3.3 Amount of fish consumed

The number of fish meals eaten over the 16-week period ranged from 1 to 73 with 51% of participants eating < 1 fish meal/week[15]. The mean number of fish meals/week was 1.12 and the mean grams of fish consumed per day was 25.1-26.8 (depending on the assumptions made about portion size). Anglers in Erie ate less fish than anglers at the other two study sites (Table 2). Older anglers, better educated anglers, and higher income anglers all ate more fish. Nonwhite anglers did not eat more fish meals/week than white anglers, but they did eat more grams/day. The amount of fish consumed by male and female anglers did not differ.

[14] Appendix G provides detailed information by study site for all questions asked in the surveys conducted at the end of Year 1 and Year 2. These include questions about socio-demographic characteristics, awareness of fish consumption guidelines, sources of information, beliefs about fish consumption, perceived changes in fish consumption behavior between Year 1 and Year 2, and awareness of the brochure sent between study years.

[15] Almost all urban anglers (91%) ate their fish meals distributed over the 16-week study period, with no single period comprising 25% or more of their total consumption. Nine percent ate 25% or more of their meals within a two-week period. These urban anglers might represent a group who ate most of their fish while on vacation, thus concentrating their exposure to potential contaminants within a short period of time.

Table 2
Amount of fish consumed by study participants.

	Fish Meals/Week[1]	Grams/Day[1,2]
Study Site		
Kalamazoo, MI	1.15[a]	25.8-27.4[a]
Erie, PA	0.98[b]	22.5-24.2[b]
Rochester, NY	1.22[a]	27.0-28.6[a]
Age		
Under 35	0.85[a]	19.4-20.8[a]
35 to 49	1.01[a]	23.2-25.1[b]
50 to 59	1.17[b]	26.2-27.9[b]
60 or over	1.39[c]	30.5-32.2[c]
Education		
High school or less	0.88[a]	20.2-21.9[a]
Some college	1.09[b]	24.7-26.5[b]
College degree or more	1.23[b]	27.3-28.9[b]
Annual Household Income		
Less than $50,000	1.03[a]	23.0-24.6[a]
$50,000-$99,999	1.06[a]	23.7-25.3[a]
$100,000 or more	1.31[b]	29.4-31.2[b]
Race		
Nonwhite	1.30[a]	30.4-33.1[a]
White	1.13[a]	25.2-26.9[b]
Total	1.12	25.1-26.8

[1]Within each category, figures with different superscripts differ significantly ($p<0.05$).

[2]The range reflects different assumptions about portion size (as described in Methods).

3.4 Types of fish consumed

A large majority (81%) of the 17.9 fish meals (mean) consumed over the 16-week study period were purchased as opposed to sport-caught fish. The proportion of sport-caught fish varied in the study sites from a low of 10% in Rochester to more than one-quarter of meals in Erie (Table 3)[16]. Some demographic groups consumed a greater proportion of sport-caught fish than others. Men ate a greater proportion of sport-caught fish than did women. The oldest group of anglers (60 years or older) consumed a lower proportion of sport-caught fish. The relative proportion of sport-caught fish consumption decreased with education and income. Nonwhite anglers consumed a greater proportion of sport-caught fish than white anglers did.

Urban anglers ate a variety of species of purchased fish, but > 70% of fish meals were of one of six types of fish: shellfish (28%), salmon (15%), canned "white" tuna (9%), canned "light" tuna (8%), haddock (7%), and tilapia (5%)[17].

[16] Appendix H describes the amount of fish eaten for each type of fish identified in the guidelines for each study site.

[17] Appendix C characterizes the number of types of purchased fish that individuals consume.

Table 3
Percentage of sport-caught fish within total fish meals.

	Percentage of Sport-Caught Fish Meals[1]
Study Site	
Kalamazoo, MI	23[a]
Erie, PA	26[b]
Rochester, NY	10[c]
Gender	
Male	20[a]
Female	15[b]
Age	
Under 35	20[a]
35 to 49	21[a]
50 to 59	20[a]
60 or over	16[b]
Education	
High school or less	29[a]
Some college	23[b]
College degree or more	15[c]
Annual Household Income	
Less than $50,000	26[a]
$50,000-$99,999	21[b]
$100,000 or more	15[c]
Race	
Nonwhite	24[a]
White	19[b]
Total	19

[1]Within each category, figures with different superscripts differ significantly ($p<0.05$).

3.5 Advisory exceedance

As described in the Methods, we present estimates of advisory exceedance as ranges because respondents did not always know the length or species of the fish they ate; in these cases we estimated exceedance using both most and least restrictive consumption recommendations. Overall, 17-22% of anglers exceeded advisory limits, but exceedance varied considerably from one study site to another: from 27-40% of anglers in Kalamazoo to 7-10% in Rochester (Table 4). Female anglers were more likely to exceed advisory recommendations than men (when estimates of advisory exceedance were based on the most restrictive consumption recommendations)[18]. Exceedance of advisories was greater for older anglers and for nonwhite

[18] Appendix I: Profiles urban anglers who are exceeding the guidelines.

anglers (using either most restrictive or least restrictive consumption recommendations). Advisory exceedance was not correlated with education or income.

Table 4
Percentage of study participants exceeding advisory recommendations[1].

	Least restrictive consumption recommendations[2]	Most restrictive consumption recommendations[2]
Study Site		
Kalamazoo, MI	27[a]	40[a]
Erie, PA	17[b]	20[b]
Rochester, NY	7[c]	10[c]
Gender		
Male	16	21[a]
Female	21	28[b]
Age		
Under 35	13[a]	17[a]
35 to 49	14[a]	21[a]
50 to 59	16[a,b]	22[a,b]
60 or over	22[b]	28[b]
Race		
Nonwhite	28[a]	39[a]
White	17[b]	22[b]
Total	17	22

[1]Within each category, figures with different superscripts differ significantly ($p<0.05$).

[2]When the species or length of fish caught was unknown, adherence to the guidelines was calculated assuming both the least and most restrictive consumption recommendations.

We selected just those individuals who exceeded the advisory recommendations based on maximum estimates in Kalamazoo (40% of participants), Erie (20%), and Rochester (10%) and calculated the relative contributions of different types of fish consumption to advisory exceedance (Table 5). The types of fish that contributed most to advisory exceedance varied from site to site. In Kalamazoo, which is the only site relying on state (rather than federal) advisories for purchased fish consumption, the consumption of too much low-mercury purchased fish made the greatest contribution to advisory exceedance. In Erie, consumption of walleye and white perch made the greatest contributions; if the consumption of walleye alone was eliminated in Erie, it would reduce the number of people exceeding the advisory recommendations by nearly 50%. In Rochester, the consumption of sport-caught lake trout (lake trout > 25" have stricter consumption limits), the consumption of any fish from Lake Ontario by women of childbearing age, and the consumption of too much low-mercury purchased fish all made similar contributions to advisory exceedance.

Table 5
Percentage reduction in advisory exceedance from eliminating certain types of fish consumption from data set.

	Kalamazoo, MI	Erie, PA	Rochester, NY
Purchased fish			
Shark	0	2	0
Swordfish	5	1	2
Too much low-mercury purchased fish[1]	21	1	10
Sport-caught fish			
Lake trout	0	8	14
Walleye	2	48	0
White perch	0	35	0
Fish from specific water bodies			
Kalamazoo River (Morrow to Allegan Dams)	5	-	-
Lake Ontario (women of childbearing age only)	-	-	12

[1]Purchased fish with recommended limits of one/week or two/week.

4. Discussion

Our characterization of fish consumption by urban anglers complements past research on this population. Nearly all past research on urban anglers has focused on subgroups of anglers that were expected to eat a lot of fish, helping to characterize fish consumption among individuals that are most likely to be exposed to contaminants in fish. In some cases, however, the sampling strategies used to select heavy fish consumers prevent generalization of the results to a larger population. Even when the results can be generalized to a larger population, these studies as a set do not provide a comprehensive picture of urban anglers and how vulnerable subpopulations are similar to or different from the larger population of anglers living in cities. The more comprehensive characterization of urban anglers that we generated in this study can inform fish consumption advisory programs because it can reveal the degree to which these subgroups may benefit from a tailored approach to communicating advisory information.

We found that the average angler consumed 1.12 meals/week of fish (with about one-fifth of those being sportfish meals) and 25.1-26.8 g/day in three Great Lakes cities during summer 2014. This estimate is equivalent to 58 total fish meals/year. Our estimate of fish consumption by urban anglers was lower than the estimates of most past studies (Hutchison and Kraft 1994, Sheaffer and O'Leary 2005, Burger 2002, Murkin et al. 2003), although Kearney and Cole (2003) and Lauber et al. (2017) produced similar or lower estimates.

Because almost all of the studies of urban anglers cited above selected for individuals expected to consume large amounts of fish, we would not expect their estimates of fish consumption to be similar to ours. Studies of representative samples of licensed anglers and sportfish consumers have produced estimates that are more similar to ours, even though they do not focus specifically

on *urban* anglers (Cole et al. 2004, Imm et al. 2005, Turyk et al. 2012, West et al. 1993). Although these findings are broadly consistent with ours, the estimates of fish consumption from these studies are quite varied, ranging from 26 to 111 total fish meals/year. Some of this variation could be attributable to methodology. With very few exceptions, the studies cited above relied on surveys or interviews and asked people either how much fish they typically ate or to recall how much fish they ate in the last three to 12 months. These studies could be expected to generate less reliable estimates than the diary method that we used. Our estimates of total fish consumption and grams/day of fish were fairly consistent across our three study sites, varying by no > 25%.

Our findings focused not just on how much fish was being consumed but the types of people consuming the most fish. We found that fish consumption increased with age, education, and income and was higher for nonwhites than for whites. These findings are consistent with the literature, although no study that we could find documented all of these patterns. Burger (2002) found that fish consumption increased with age. Imm et al. (2005) reported that more educated individuals ate more fish. Lauber et al. (2017) and Imm et al. (2005) reported fish consumption increased with income.

The findings on racial differences in fish consumption are more complicated. Our sample was 92-95% white, which, based on other studies using similar methodology, probably underrepresents racial minorities (Bray and Schramm 2001, Lusk and Brooks 2011). Although we found higher fish consumption among nonwhites, we were unable to distinguish different nonwhite racial groups because of our sample size. Most studies of racial patterns in fish consumption in urban anglers have focused on Asian ethnic groups and may not directly compare these individuals to other ethnic groups. Hutchison and Kraft (1994) reported high levels of consumptions for a Hmong community, but did not collect data on whites. Murkin et al. (2003) compared Asian-born fish consumers with European-, Canadian-, and U.S.-born, and found that Asian-born ate more fish. Although these findings are compatible with ours, anglers of Asian or Pacific Islander descent made up only 23% of our nonwhite sample (n=19), limiting our ability to characterize racial differences in detail.

In addition to our analysis of fish consumption, we also estimated advisory exceedance. The only other study we found that produced similar estimates of advisory exceedance was Connelly et al.'s study of Lake Ontario anglers (Connelly et al., 1996), which reported 36% of anglers exceeding advisory limits; this was somewhat higher than our estimate of 17-22% across all three study sites. In our study, exceedance was higher for older anglers, women, and nonwhites, but it did not differ significantly with education and income despite the fact that better educated and higher income anglers tended to consume more fish. The finding that women and nonwhites are more likely to exceed advisories has rarely been documented elsewhere, but is often expected because advisories are more stringent for women of childbearing age and some nonwhite angler populations have been shown to consume more fish (see above). The higher rate of advisory exceedance in older anglers is not as widely recognized, however, and suggests the potential benefits of directing special attention to older anglers in advisory programs.

We also found that advisory exceedance varied a great deal geographically, ranging from 7-10% in Rochester, NY, to 27-40% in Kalamazoo, MI, despite similar levels of fish consumption at the

three sites. There are several reasons for these differences. Advisory programs at the three sites have adopted different approaches. In particular, Kalamazoo, with the highest rates of exceedance, also has the most detailed advisory for purchased fish consumption. The purchased fish advice in Kalamazoo was developed by the State of Michigan and includes all consumers, whereas for the other two sites, we used the simpler federal purchased fish advice which applies only to women of childbearing age (who make-up a small portion of the angler population) in evaluating compliance with advisories. Indeed, purchased fish consumption contributes substantially to advisory exceedance in Kalamazoo.

In addition to the differences in the advisories, the types of fish that are most likely to expose anglers to contaminants varies from site to site because the species that are available to catch, and their contaminant loads, vary from city to city. In Erie, consumption of walleye and white perch have a considerable influence on advisory exceedance, and these are sportfish that many anglers catch in Lake Erie. These species have little to no effect on advisory exceedance at the other two sites.

These findings have practical value for advisory programs. They demonstrate or confirm that certain audiences, namely women, older anglers, and nonwhites, are more likely to exceed the advisories. Indeed, many fish advisory programs direct special attention to women and nonwhite anglers, in particular. We also reported novel findings regarding the types of fish that contribute to advisory exceedance, demonstrating considerable variation in these types of fish from site to site. Although advisory programs understandably attempt to provide comprehensive consumption advice for fish for particular locations, there is the potential for anglers to be overwhelmed by the amount of information they receive in these advisories. Recognizing that certain species are most likely to contribute to exceedance suggests that highlighting the importance of monitoring the consumption of particular species could play an important role in protecting the public health, but such a community-specific approach to advisories would be resource-intensive.

Some of the limitations of our study relate to the audience on which we focused. We studied only *licensed* anglers and not unlicensed anglers. The U.S. Environmental Protection Agency has identified unlicensed anglers as a group of special concern, which might consume more fish, be less aware of advisories, and, therefore, be at greater risk (USEPA 2001). However, we are aware of no good estimates of how fish consumption by licensed and unlicensed anglers differs. Sheaffer and O'Leary (2005) have argued that documenting the differences between licensed and unlicensed anglers is an important research need, and this need still remains.

We also restricted the anglers in our sample to those who ate at least some fish and focused on their fish consumption over the summer, when they tend to eat more sport-caught fish (Connelly et al. 1996). Therefore, we may overrepresent annual consumption of sport-caught fish by licensed urban anglers. Connelly et al. (1996) reported that between May and September (the months we collected data), sport-caught fish comprise 34% of all fish consumed. During the other months, sport-caught fish comprise 27% of fish consumed. Murkin et al. (2003) similarly found that the consumption of Great Lakes fish was highest in the summer – nearly 3 times higher than it was in the fall and > 3-1/2 times higher than it was in the winter. At sites such as Erie, PA, therefore, where advisory exceedance is strongly linked with sport-caught fish

consumption, our methods may have resulted in higher estimates of advisory exceedance than we would have found if we collected fish consumption data over an entire year. By collecting data on consumption during the period when licensed anglers are likely to eat the most fish, however, we ensure that our estimates reflect the periods when health risks are greatest.

Finally, although we relied on advisory exceedance as an indication of health risk, our measure of advisory exceedance was imperfect. Accurately measuring advisory exceedance depends on detailed information about the amounts and types of fish eaten. Our on-line diary provided respondents with the opportunity to present such detailed information about the fish they caught in their home counties; drop-down menus in the diary allowed them to list species, fish length, and body of water for all species and waters with advisories. For fish caught in their home states, but outside of their home counties, however, they could only list species identified in statewide advisories, but not the bodies of water in which they caught the fish. Consequently, we could not evaluate whether or not fish were caught in bodies of water with special advisories outside of their county of residence. Although our diary method allowed us to collect detailed information on fish consumption, even more detailed information would have allowed us to make more accurate judgments about advisory exceedance.

Regardless of the level of detail on fish consumption provided by the participants, however, our method depended on the assumption that participants knew what type of fish they were eating and reported it accurately during each two-week reporting window. For sport-caught fish, participants would need to recognize the species they were eating and accurately remember fish length. In cases in which they were served fish by others, we can assume that they would be less likely to have this information. Some individuals also reported meals in which they ate multiple kinds of fish. These uncertainties were the reason we presented a range of estimates of advisory exceedance, but these ranges would not capture those circumstances in which participants misremembered or mistakenly identified the type of fish they ate.

In addition, we could not precisely assess portion size of fish meals, which is necessary for judging advisory adherence. While we provided participants with a photo of an 8 oz. pre-cooked (6 oz. cooked) serving of fish and asked them whether the portion they ate for each meal was the same size, larger, or smaller, this approach does not provide precise estimates. In addition, state advisories consider not only portion size, but the consumer's body weight. In Michigan, for example, an 8 oz. portion is a fish meal for a 180 lb. person. In Pennsylvania, an 8 oz. portion is a meal for a 150 lb. person. We had no information about our participants' weights, and so were further limited in being able to judge whether they met advisory recommendations.

Even an accurate method of advisory exceedance is not perfectly correlated with health risks. Women of childbearing age, for example, are advised to eat less fish then men or older women. This advice, however, is based on the premise that women of childbearing age may bear and nurse children; women who do not intend to have children are less at risk than other women. In addition, advisory exceedance is a dichotomous measure; consumers either exceed advisory recommendations or they do not. Risk, however, is correlated with the amount of contaminants consumed. Clearly, the public health implications differ depending on the degree to which anglers exceed advisory limits.

Although our work has improved on past estimates of fish consumption and advisory adherence, we believe future work could offer additional improvements. Most importantly, we think it would be worthwhile to link detailed data on fish consumption with data on contaminant levels in different types of fish. This approach would allow researchers to generate estimates of contaminant loads from fish consumption, which would provide a superior measure of health risks rather than a simple dichotomous measure of advisory exceedance.

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SECTION 6: EFFECTS OF AN ADVISORY BROCHURE ON FISH CONSUMPTION OF URBAN ANGLERS IN THE GREAT LAKES REGION*

ABSTRACT: Past research has suggested that urban anglers are a group at high risk of being exposed to contaminants from fish consumption. Fish consumption advisories have been used in many regions to encourage healthy fish-eating behaviors, but few studies have been designed to assess whether these advisories actually influence behavior as intended. We conducted a large-scale, randomized experiment to test the influence of an advisory brochure on urban anglers' fish consumption. We collected detailed information on anglers' fish consumption in three urban counties in the Great Lakes region in the summers of 2014 and 2015. We provided a treatment group with fish consumption guidelines in an advisory brochure before the summer of 2015 and compared their change in fish consumption to a control group. The brochure led to a reduction in fish consumption for anglers who ate the most fish; these anglers reduced their consumption of high-contaminant purchased fish (by ≥ 0.2 meals/summer for those in 72nd percentile of fish consumption or above), high-contaminant sport-caught fish (by ≥ 0.4 meals/summer for those in 87th percentile and above), and low-contaminant sport-caught fish (by ≥ 0.3 meals/summer by those in 76th percentile and above). The brochure also reduced sport-caught fish consumption among those anglers who exceeded the advisories in 2014 (by 2.0 meals/summer). In addition, the brochure led to small increases in sport-caught fish consumption (0.4 to 0.6 meals/summer) in urban anglers who ate very little sport-caught fish (≤ 1 meal/summer).

KEYWORDS: fish consumption; advisories; urban anglers.

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1. Introduction

Researchers and government agencies have directed attention to urban anglers because of concerns that they could be exposed to contaminants, such as PCBs and mercury, through fish consumption [1-8]. Urbanization is correlated with the presence of PCBs, and fish in urban waters may be more likely than fish in other waters to accumulate these contaminants [9-10]. In many states, certain bodies of water in urban areas have fish consumption advisories that are more restrictive than advisories for other waters (e.g., https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/). Anglers who live in urban areas are more likely to fish in these contaminated waters because anglers are most likely to fish close to their homes [11]. If they eat the fish they catch, these anglers could be exposed to the contaminants in these fish.

A number of studies of urban anglers or urban residents who eat fish have reported relatively high levels of fish consumption compared to the population at large. Most of these studies, however, have focused on particular subpopulations who were expected to consume a lot of fish because of their ethnicity [12-13], fishing site selection [14], or the results of a screening process [15]. Using baseline data collected prior to the current intervention, Lauber et al. [2] studied fish consumption in a representative sample of urban anglers in three Great Lakes counties using a diary method in which participants recorded data on all of their fish meals over a four-month period. They reported a mean of 1.12 meals/week across the three urban sites, with evidence of excessive consumption by some anglers. The percentage of anglers exceeding fish consumption advisory recommendations ranged from a low of 7-10% at one site to a high of 27-40% at another. Women, older anglers, and nonwhites were more likely to exceed advisory recommendations.

Fish consumption advisories are used throughout the Great Lakes region and elsewhere to encourage safe fish consumption. Most studies of the effectiveness of these advisories are limited, using indirect evidence to infer whether or not advisories lead to safer fish-eating behaviors. A number of studies have reported rates of compliance with advisories [2, 16-18], but do not assess whether the advisories are contributing to that compliance. Other studies have explored the prevalence of various antecedents to advisory compliance. For example, Beehler et al. [19-20] and Burger et al. [3] documented urban anglers' awareness of advisories. Some authors have studied whether fish eaters believe or correctly understand key advisory messages [4, 21-22]. Chess et al. [23] and Burger et al. [24] assessed which approaches to communicating advisory messages are most effective at encouraging correct beliefs. Studies have also explored the advisory formats and messages that are preferred by urban anglers [5] or anglers in general [25]. This body of work is valuable, as urban anglers must be aware of advisories, find them accessible, and correctly understand their messages before the advisories can influence fish consumption.

None of these studies, however, provides evidence that advisories actually influence behavior. Only a few studies have attempted to answer this question, and none of them have specifically targeted urban anglers. The most common approach to assessing the influence of advisories on behavior has been to explore whether awareness or receipt of advisories is associated with safe fish consumption patterns. For example, Silver et al. [16] reported that fish consumption was lower for women who were aware of advisories. Teisl et al. [26] surveyed women to find out

whether they had received a fish advisory brochure and compared the fish consumption of those who did and did not receive the brochure before, during, and after pregnancy. Although studies like these show a connection between advisory awareness and fish consumption behavior, they are correlational and so cannot establish causation. The types of people who are aware of or remember receiving advisories may differ from those who do not. For example, those who remember advisories might be more conscious of their diet and the amount and types of fish they consume and thus attuned to dietary information. They might have eaten different amounts of fish regardless of whether or not they received the advisory.

Shimshack et al. [27] took a different approach and studied how consumer purchases of fish changed after the issuance of the FDA/EPA advisory for mercury in fish. To do this, they took advantage of the Bureau of Labor Statistic's CEX, an annual survey that collects data on all household expenditures. They looked at how purchases of canned fish changed after the advisory was first issued. They found that some targeted groups reduced canned fish purchases as a result of the advisory and concluded that issuing the advisory could influence behavior, but they did not focus on urban anglers or other high-risk groups of anglers.

Roosen et al. [28] and Verger et al. [29] took an experimental approach to establish the effects of advisories. They tracked fish consumption in a sample of individuals for three months (in two separate periods) in France. A treatment group received a message about mercury in fish and recommendations for fish consumption during an in-person visit. Both studies found small decreases in fish consumption in the treatment group compared to a control group. Both also found, however, that consumption of the most contaminated fish did not decrease, and neither study examined urban anglers.

Given that experimental evidence of the effectiveness of fish consumption advisories is limited, and no such evidence is available for urban anglers, we conducted a large-scale, randomized experiment to test the influence of an advisory brochure on urban anglers' fish consumption. Brochures (both print and web versions) are frequently used to communicate advisory information in the Great Lakes region and are suitable for reaching large audiences. We collected detailed information on urban anglers' fish consumption in three counties in the Great Lakes region in the summers of 2014 and 2015. We provided a treatment group with fish consumption guidelines in an advisory brochure before the summer of 2015 and compared their change in fish consumption to the change in fish consumption of a control group that did not receive the experimental brochure.

2. Methods

2.1. Overview

We collected baseline fish consumption data from a sample of urban anglers in the summer of 2014 (May 18-September 6). We implemented an intervention with a randomly selected subset of these anglers by sending them a fish consumption advisory brochure on May 11, 2015. We collected additional fish consumption data from the same anglers in the summer of 2015 (May 17-September 5) to determine whether and how fish consumption changed in those anglers who received the intervention, relative to those who were not randomly selected to receive it.

2.2. Sample Selection and Diary Recruitment

For the purposes of this study, we defined "urban anglers" as anglers who live in urban counties and, therefore, in close proximity to urban waters. We drew a sample of 15,000 fishing licenses sold to licensed anglers who lived in one of three urban counties in the Great Lakes region: Kalamazoo County, MI, Erie County, PA, and Monroe County, NY. Each of these study sites had populations of at least 250,000 people, and the percentage of the population classified as urban ranged from 80-94%. We drew 5,000 licenses from each site.

We sent invitation letters to each member of the sample in February 2014. The letter described the study and what would be required of participants. It also offered a financial incentive of up to $45 for participation in the project and provided a link to a sign-up page on the Internet. We provided a postage-paid return postcard for people to opt out of the study because they did not eat fish, did not have regular Internet access, or were not interested in participating. We sent a follow-up letter to all invitees a week later encouraging participation.

From March through May 2014, we called those who did not sign up or return a postcard to encourage participation and allow them to sign up over the telephone. Calling ceased when at least 600 participants had been recruited for each study site. During the study sign-up process we obtained email addresses and then checked them by sending out a study participation verification email. Email was then used for all communication with study participants.

2.3. Diary Data Collection

We collected fish consumption information for 16 weeks in the summer of 2014 (May 18- September 6, 2014) and 16 weeks in the summer of 2015 (May 17- September 5, 2015). Participants recorded data in two-week blocks during these periods. Participants could record information as many times as they wished during each two-week period. Every two weeks we sent an email invitation to participants to signal the start of the next two-week period and remind them that the previous two week-period was ending. When a two-week period ended, we sent up to three reminders to participants who had not completed entering data for the period to finish recording their information for the period. Participants earned a $2 financial incentive for each period completed and received a $5 bonus at the end of the first year (September 2014) and $9 at the end of the second year (September 2015) if they completed reporting for every period.

We gave each participant a link unique to them to access their personal fish consumption diary on the Internet. On the initial page, participants saw information for the eight two-week periods of the study, showing completed periods and incentives earned. On the next page we asked participants to record whether or not they ate fish on each day in the current two-week period. For each day they indicated they ate fish, another page opened asking the number of fish meals they had eaten on that day. For each meal reported, participants recorded whether the fish was purchased (at a store or restaurant) or sport-caught (i.e., fish caught by you or someone else), the species eaten, and (for sport-caught fish) where the fish was caught. To specify the location where sport-caught fish were caught, participants could choose from a drop-down list of water bodies in each urban county that had special advisories for the fish caught there, or they could choose "other" if the location where the fish was caught was not on the list. Participants were not told that the list was limited to waters with special advisories. To specify the species of fish consumed, participants could choose from a drop-down list of fish species, which included the

most commonly consumed purchased fish and those with consumption guideline recommendations, along with a text box to record species not on the list. Participants could also check that they had consumed "multiple species." For sport-caught species, we listed only those with consumption guideline recommendations and provided an "other" option; participants were not told that only those species with consumption guideline recommendations were on the list. Participants indicated portion size in reference to a picture of a 6 oz. cooked (170 grams) portion of salmon (Figure 1); we asked participants if the meal they ate was larger, smaller, or the same size as the picture. Previous studies have estimated the size of fish portions that people eat using pictures similar to those used in our study [18, 30] or plastic models [16].

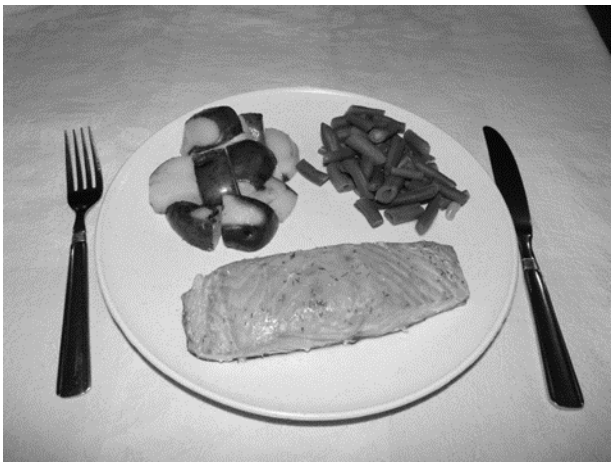

Figure 1. Picture shows a 6 oz. piece of cooked salmon (8 oz. pre-cooked).

We obtained data on participant age and gender from fishing license records. We gathered data on other socio-demographic characteristics, such as education and race, using an online survey conducted during the last 2-week period of diary data collection.

2.4. Intervention

We developed a single-page, bifold fish consumption guidelines brochure to serve as the intervention in this study (Figures 2-4). We worked collaboratively with the Great Lakes Consortium for Fish Consumption Advisories to develop a brochure that emphasized fish consumption messages that state agencies wanted to communicate in the Great Lakes region. We based these messages on several years of research and dialogue with the Consortium. This research had explored factors influencing fish consumption [5, 31-32] and how people responded to advisory messages [5, 33-34]. In addition, we synthesized findings and insights about effective fish consumption advisories from the literature and experts in the region [35].

We designed different versions of the brochure for each of our three study sites, listing the fish consumption guidelines for those sites, including guidelines for local bodies of water with special advisories. The fish consumption messages were the same for each site, however. The key messages were designed to encourage recipients to follow the fish consumption guidelines for their county (Table I).

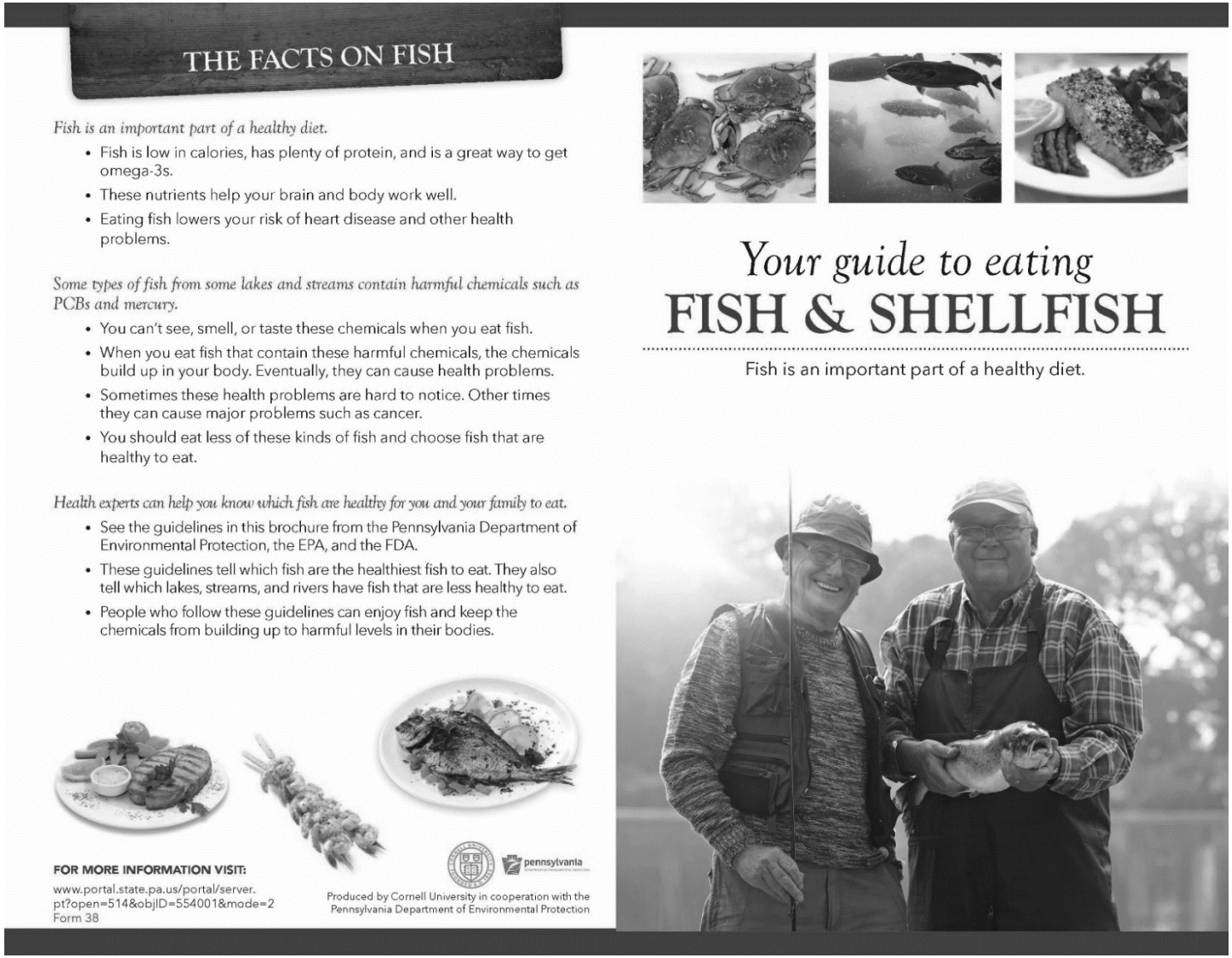

Figure 2. Example of the front and back cover of the brochure.

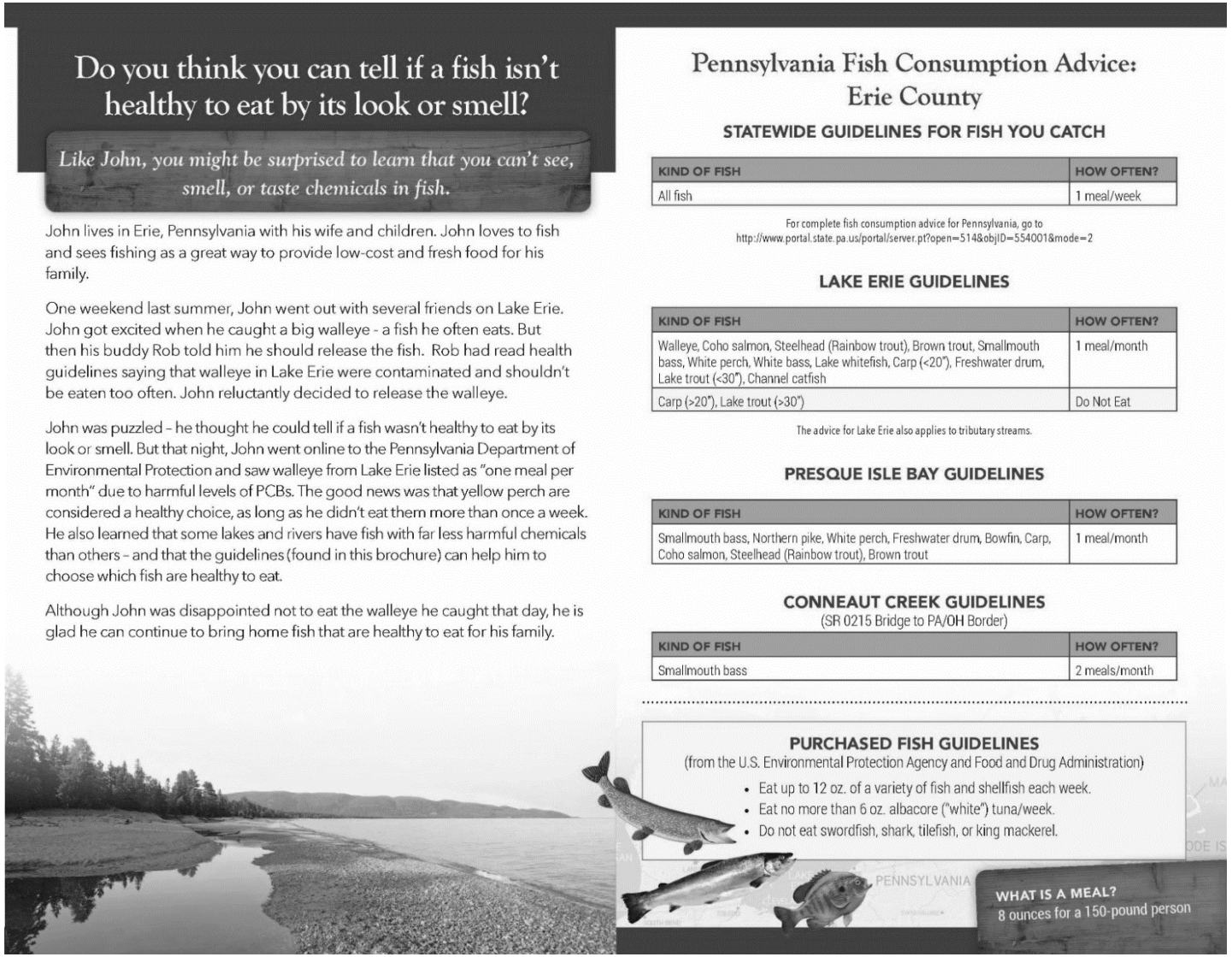

Figure 3. Example of the inside pages of a "narrative" version of the brochure.

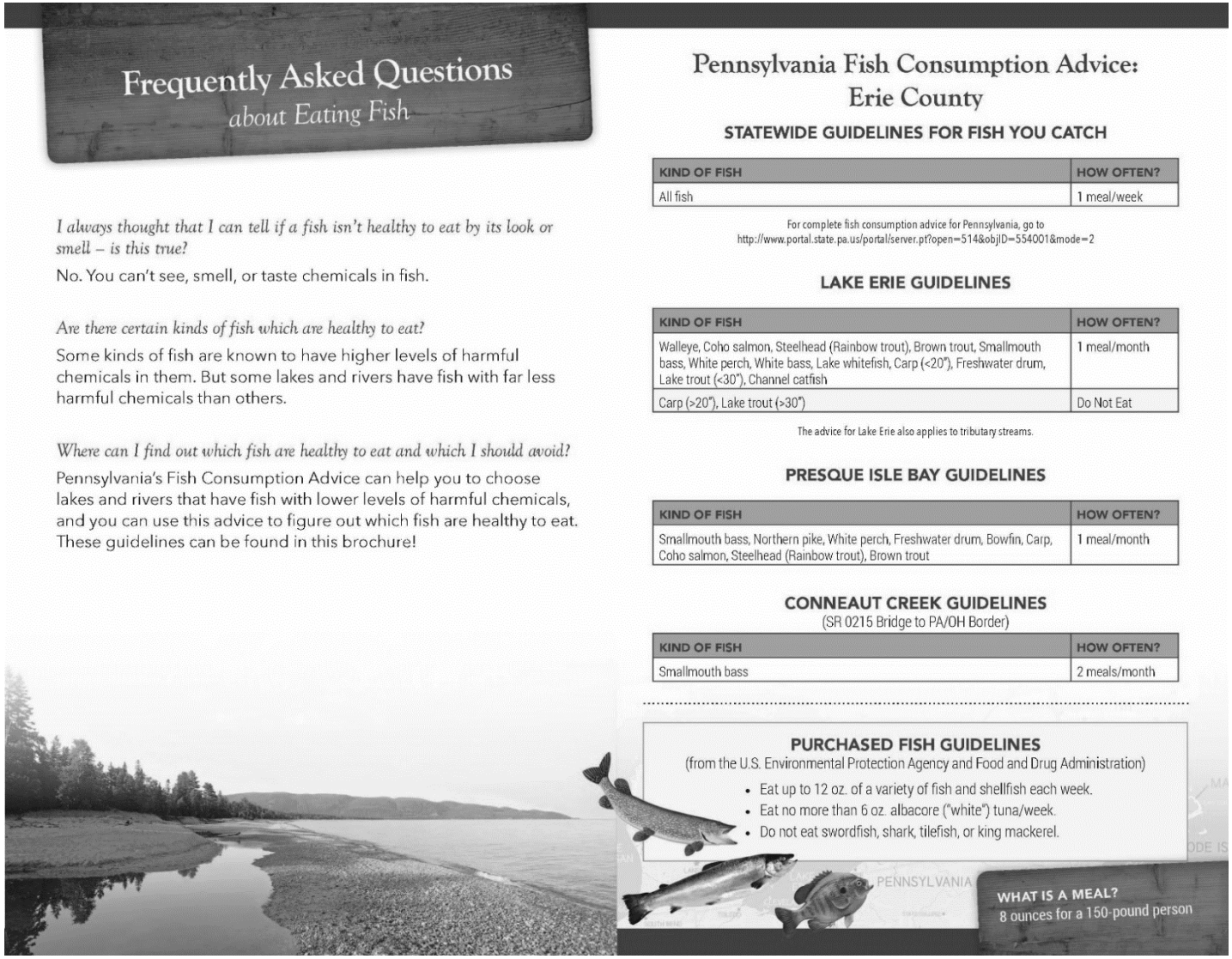

Figure 4. Example of the inside pages of an "FAQ" version of the brochure.

Table I. Key messages about fish consumption in advisory brochure.

Fish is an important part of a healthy diet.

- Fish is low in calories, has plenty of protein, and is a great way to get omega-3s.
- These nutrients help your brain and body work well.
- Eating fish lowers your risk of heart disease and other health problems.

Some types of fish from some lakes and streams contain harmful chemicals such as PCBs and mercury.

- You can't see, smell, or taste these chemicals when you eat fish.
- When you eat fish that contain these harmful chemicals, the chemicals build up in your body. Eventually, they can cause health problems.
- Sometimes these health problems are hard to notice. Other times they can cause major problems such as cancer.
- You should eat less of these kinds of fish and choose fish that are healthy to eat.

Health experts can help you know which fish are healthy for you and your family to eat.

- See the guidelines in this brochure from the [relevant state or federal agencies].
- These guidelines tell which fish are the healthiest fish to eat. They also tell which lakes, streams, and rivers have fish that are less healthy to eat.
- People who follow these guidelines can enjoy fish and keep the chemicals from building up to harmful levels in their bodies.

We randomly assigned study participants either to receive the brochure intervention (two-thirds of the sample) or to be part of a control group (one-third of sample), which did not receive the brochure. For those receiving the brochure, two elements of the brochure content were varied in a 2x2 experimental design leading to 4 versions of the brochure. Members of the treatment group were randomly assigned to four equal groups, each of which received a different version of the brochure. The two elements of the brochure that were varied to test the comparative effectiveness of different approaches to communicating advisory information were elements that relevant Great Lakes government agencies were considering for their advisory communication efforts (Figures 3-4). They were:

- On the second page of the brochure, key messages about fish consumption were presented in two different formats: a frequently asked questions (FAQ) format, in which the messages were presented as answers to three questions about fish consumption; and a narrative format in which the same messages were incorporated into the form of a story about a hypothetical urban angler. Narratives often are more effective than non-narrative messages in shaping attitudes and behavior because they are easy to understand, create emotional connections with story characters, and reduce counterarguing of message content.[36-40]
- Language was varied throughout the brochure to reflect more certainty about fish consumption recommendations in one version and less certainty about recommendations in other versions. For example, the "certain" version included the text "Fish is an important part of a healthy diet" on the first page. The "uncertain" version included the text "Fish can be an important part of a healthy diet." In addition, the last page of the uncertain version contained an additional bullet point conveying uncertainty: "It is

> difficult to know who might have health problems from chemicals in fish. Some people can be fine after years of eating fish with these chemicals in them, while others can have health problems." Evidence on the impact of certain versus uncertain language in describing risk and benefit information is less clear than the evidence for narratives [41-43] with federal agencies noting the need for research on how to best communicate information laden with various forms of uncertainty, including deficits in the evidence base and the probabilistic nature of causality in epidemiological studies.[43]

These variations allowed us to test the relative effects of different variations of the brochures on encouraging anglers to follow the advisories.

For those individuals in one of the treatment groups, hard copies of the brochure were sent to them by mail on May 11, 2015, shortly before data collection for the second year began. The brochure was also available to them electronically on the website on which they entered their fish consumption records.

2.5. Data Analysis

We compared the meals eaten by each participant to the guidelines of the state where they lived. We characterized participants as adhering to the guidelines if they kept their total consumption for the 4-month study period within the recommendations for that time period. For example, if the recommendation was to consume no more than one serving of coho salmon per month from Lake Michigan, and a person consumed five servings of coho salmon during the 4-month study period, we concluded that he or she had exceeded the guidelines. We measured fish consumption against the guidelines for local bodies of water, the statewide guidelines for all other sport-caught fish, and the state guidelines (or federal guidelines if no state guidelines existed) for purchased fish. If an individual exceeded any of these guidelines, we concluded that he or she exceeded the guidelines.

We present some results as ranges because some advice is based on the length of the fish caught; if consumers did not know the length of the fish they ate (1% of meals), we estimated their adherence to the guidelines assuming both the most and least restrictive consumption recommendations for that species. Similarly, a few consumers did not know the species of fish they were eating (1% of meals), or more commonly, reported eating multiple species at one meal (6% of meals). In these cases, we estimated their adherence to the guidelines assuming both the most and least restrictive consumption recommendations for the water where the fish was caught.

We analyzed data from the diary using SPSS (IBM SPSS Statistics 20). We used chi-square tests to identify statistically significant differences between cities at the $P < 0.05$ level. Any differences described in the narrative text are statistically significant at this level. We used Scheffe's test to identify differences in portion sizes based on species of fish consumed. We used linear regression to explain differences in fish consumption based on available demographic data.

We developed logistic regression models to predict adherence to the advisories in year 2, while controlling for advisory exceedance in year 1. We developed OLS regression models to estimate the number of total, purchased, and sport fish meals consumed in year 2, while controlling for

meals consumed in year 1. We tested for the main effects of: (a) being in the experimental group (receiving a version of the brochure) vs. control; (b) the narrative version of the brochure vs. the FAQ version vs. control; and (c) the certain version of the brochure vs. the uncertain vs. the control. We tested for interactions between the narrative-FAQ variation and the certain-uncertain variation. Because we predicted that the effects of the intervention would be most apparent among those who were most at risk because they exceeded advisory guidelines and/or frequently consumed fish, we also tested for interactions between: (a) whether participants exceeded advisory guidelines at baseline and the intervention; and (b) baseline levels of fish consumption and the intervention. We included demographic variables as covariates. In some variations of these regressions, we predicted consumption of only low-contaminant fish (fish for which recommended consumption limits were once/week or more) or high-contaminant fish (fish for which recommended consumption limits were less than once/week).

We combined the data from the three sites in our analyses of the results of the experiment. Because we assigned one-third of our sample to be in the control group and divided the remaining two-thirds into four experimental groups, each of which received a different version of the intervention, the smallest two groups we compared had approximately 165 individuals in each of them. With this sample size per group we would be able to call significant an effect size of 0.31 in our OLS regressions (i.e. a difference in mean between 2 groups equal to 0.31 standard deviation) with a power of 80%, an alpha level of 0.05 and a two-sided test. Even if we conservatively applied a Bonferroni correction because we were making multiple comparisons between our experimental groups, we could detect an effect size of 0.40, which is still a small to medium effect size.

We probed interactions in the regressions using the Johnson-Neyman technique to identify levels of the moderator (fish meals consumed in year 1) at which effects of the dependent variable (brochures) were statistically significant [44]. When significant interactions existed between baseline fish consumption levels and the intervention, this technique allows us to draw conclusions about the baseline fish consumption levels above and below which the effects of the intervention were significant.

3. Results

3.1. Diary Recruitment and Participation Rates

We were able to make contact with 5,384 individuals out of our initial sample of 15,000 fishing licenses (Figure 5). Individuals were ineligible to participate if they did not eat fish (n = 490, 9%) did not have email or web access (n = 405, 8%), or did not speak English (n = 23, 0.004%). We recruited 2,099 study-eligible licensed urban anglers (39% of the individuals contacted) to participate in the study. Anglers who agreed to participate were slightly older (47.6) than other anglers in the sample pool (45.5, $p<0.001$), but the gender ratio did not differ. Seventy-six percent of the urban anglers we recruited (N = 1,587) participated in the first two-week period in 2014, 1,378 (66%) participated throughout the 16-week study period in 2014, and 1,041 (50% of those recruited and 19% of the original sample pool) completed the diaries in both 2014 and 2015 and are included in the analyses in this manuscript. After attrition from the sample of 2,099 anglers who were recruited, we retained the approximate number and percentage of individuals we wanted in each of our experimental groups: 344 individuals (33% of analytical sample) in the control group, 176 (17%) who received the narrative-uncertain brochure, 179 (17%) who

received the narrative-certain brochure, 162 (16%) who received the FAQ-uncertain brochure, and 180 (17%) who received the FAQ-uncertain brochure.

We compared respondents who participated fully in both 2014 and 2015 to those who participated fully in 2015 but not 2014. Anglers who participated fully in both 2014 and 2015 were somewhat older than those who participated fully in 2015, but not 2014 (48.6 vs. 42.1, p=0.01). Their household income, education level, race, and gender did not differ.

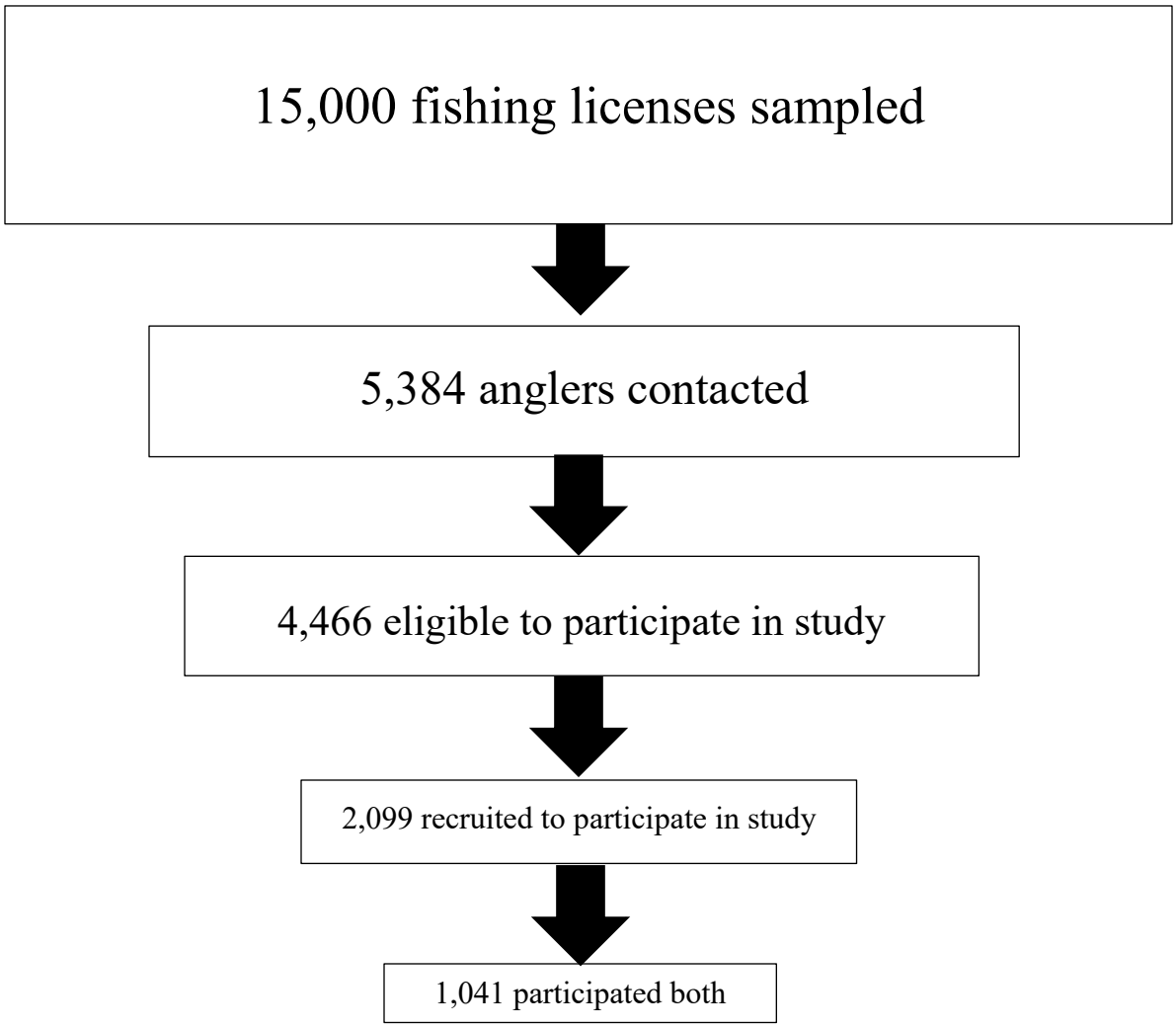

Figure 5. Derivation of analytical sample.

3.2 Validity and Reliability

To assess convergent validity, we compared participants' changes in fish consumption behavior between 2014 and 2015, as reflected in the diaries with their beliefs, about how their fish consumption changed, as reflected by a questionnaire they completed at the end of the study. Those who thought they ate more fish meals in 2015 also reported eating more in their fish

consumption diaries. Those who thought they ate fewer fish meals ate less fish in 2015 in comparison to those who did not think their fish consumption had changed.

Using only members of the control group, we also found evidence of test-retest reliability in the type and amount of fish eaten between 2014 and 2015. Those individuals who ate or did not eat purchased fish in 2014, were very likely to do the same in 2015. With regard to the amount of fish consumed, we found that over 75% of participants were consistently above or below the median for measures of all fish, purchased fish, and sport-caught fish in both 2014 and 2015.

3.3. Angler Characteristics by Study Site

Between 300 and 400 anglers in each of the study sites completed the diaries throughout both 2014 and 2015. The characteristics of the participants were fairly similar in all three sites (Table II). They were predominantly white (93-97%) and male (80-83%). The mean age ranged between 45 and 51 years with Erie County anglers significantly younger. The median household income level was in the $75,000-$99,999 range at all three sites. The most substantial difference between sites was in level of education. Sixty-four percent of participants in Kalamazoo County had a college degree while only 49% of those in Erie County did; Monroe County anglers were in the middle at 57%.

Nonwhite anglers included Black or African American (38%, n=18), Asian or Pacific Islander (30%, n=14), Native American or Indian (15%, n=7), and Other (23%, n=11). Because of the small sample size for every racial category except White, we compared white and nonwhite anglers in our analyses.

Table II. Characteristics of diary participants by study site (n=1,041).

	Kalamazoo County, MI (n=316)	Erie County, PA (n=349)	Monroe County, NY (n=376)
Age (%)			
Under 35	19	26	22
35 to 49	28	29	25
50 to 59	21	38	25
60 or over	33	17	29
Gender – % male	81	83	80
Annual Income (median)	$75,000-$99,999	$75,000-$99,999	$75,000-$99,999
Education – % w/ college degree	64	49	57
Race – % white	97	96	93

3.4. Fish Consumption and Advisory Exceedance at Baseline (2014)

The number of meals of fish consumed over the 4-month study period in 2014 ranged from 15.32 meals in Erie County to 19.43 meals in Monroe County (Table III). Most of the meals were purchased fish meals, although the percentage varied from site to site with a low of 73% in Erie County to a high of 90% in Monroe County. Anglers in Erie County ate fewer total fish meals and purchased fish meals than anglers at the other two sites. Anglers in Monroe County ate fewer sport-caught fish meals and more purchased fish meals. The number of fish meals (purchased,

sport-caught, and total) decreased in 2015. The decrease in purchased fish meals in Monroe County (1.27) was larger than that in Kalamazoo County (0.23) or Erie County (0.45), and the decrease in sport-caught fish meals was larger in Erie County (1.01) than in Monroe County (0.34).

Table III. Mean number of fish meals consumed by urban anglers at each study site over the 16-week study periods in the summers of 2014 and 2015[1] (n=1,041).

	Kalamazoo County, MI (n=316)	Erie County, PA (n=349)	Monroe County, NY (n=376)
2014			
Purchased fish	13.84[a] (SD = 11.98)	11.20[b] (SD = 9.98)	17.57[c] (SD = 12.32)
Sport-caught fish	4.16[a] (SD = 4.16)	4.12[a] (SD = 5.54)	1.86[b] (SD = 3.47)
Total fish	18.00[a] (SD = 13.09)	15.32[b] (SD = 11.01)	19.43[a] (SD = 12.59)
2015			
Purchased fish	13.98[a] (SD = 12.01)	11.51[b] (SD = 10.77)	16.35[c] (11.38)
Sport-caught fish	3.33[a] (SD = 5.47)	3.12[a] (SD = 4.18)	1.52[b] (SD = 2.89)
Total fish	17.31[a] (SD = 12.84)	14.63[b] (SD = 11.22)	17.86[a] (SD = 11.62)

[1]Within each row, figures with different superscripts differ significantly ($p<0.05$).

Because urban anglers sometimes ate meals containing multiple species or occasionally did not know the length or species of fish they had eaten, we estimated advisory exceedance assuming both the least and most restrictive relevant consumption recommendations. Overall, 17-22% of anglers exceeded advisory limits in 2014 (Table IV), but the proportion varied considerably from one study site to another: from 27-40% of anglers in Kalamazoo County to 7-10% in Monroe County. In 2015, advisory exceedance ranged from 26-37% in Kalamazoo County to 2-3% in Monroe County. Female anglers were more likely to exceed advisory guidelines than men (Table V). Exceedance of advisories was greater for older anglers and for nonwhite anglers (Table V). Advisory exceedance was not correlated with education or income.

3.5. Experimental Results

We detected no effects of the brochure on advisory exceedance, so the remaining results portray the effects of the brochure on fish consumption. The intervention led to a small but significant drop in the number of fish meals eaten by the treatment group compared to the control group ($p=0.016$). The version of the brochure did not matter. The treatment group ate 1.30 (SE=0.26) fewer meals in 2015 than in 2014. The decrease in fish meals in the control group (0.20, SE=0.38) was nonsignificant. A similar pattern was detected for purchased fish consumption. Those anglers who received the brochure ate 0.57 (SE=0.25) fewer purchased fish meals on average than in 2014, which was significantly different from a nonsignificant increase of 0.44 (SE=0.36) purchased fish meals in the control group. For sport-caught fish meals, the pattern was different. Anglers ate fewer sport-caught fish meals in year 2 in both the treatment group (0.75 fewer meals, SE=0.10) and the control group (0.62 fewer meals, SE=0.15), and these decreases were not significantly different from each other.

Table IV. Advisory exceedance by study site[1] (n=1,041).

	2014		2015	
	Least restrictive consumption recommendations	Most restrictive consumption recommendations	Least restrictive consumption recommendations	Most restrictive consumption recommendations
Kalamazoo County, MI (n=316)	25.7%	40.3%	25.7%	37.3%
Erie County, PA (n=349)	19.2%	22.3%	13.5%	14.3%
Monroe County, NY (n=376)	4.0%	6.9%	1.5%	2.8%

1 When the species or length of fish caught was unknown, adherence to the guidelines was calculated assuming both the least and most restrictive consumption recommendations.

Table V. Advisory exceedance (assuming least restrictive consumption recommendations[1]) by study participant characteristics in 2014[2] (n=1,041).

	Percentage
Gender	
Male[a]	14%
Female[b]	23%
Age	
Under 35[a]	12%
35 to 49[a,b]	15%
50 to 59[a]	14%
60 or over[b]	21%
Race	
Nonwhite[a]	29%
White[b]	16%

[1]When the species or length of fish caught was unknown, adherence to the guidelines was calculated assuming both the least and most restrictive consumption recommendations.
[2]Within each category, figures with different superscripts differ significantly ($p<0.05$).

Because fish consumption guidelines are intended to reduce consumption of contaminated fish in only those individuals who are at risk, we assessed whether the effect of the brochure intervention was moderated by anglers' level of fish consumption in 2014 or by whether individuals exceeded the fish consumption guidelines in 2014. We developed OLS regression models to estimate the number of total, purchased, and sport fish meals consumed in year 2 for anglers who did and did not receive the intervention, while controlling for meals (total, purchased, or sport-caught) consumed in year 1.

To test whether the effects of the brochure differed for those anglers who consumed greater amounts of fish in 2014, we allowed for an interaction term between the number of meals

consumed in 2014 and "intervention." The improvement in the models was almost significant (p=0.060) for total fish consumption and significant for purchased fish consumption (p=0.035) and sport-caught fish consumption (p<0.001) (Table VI). The results for the significant models from Table VI are depicted graphically in Figures 6 and 7. Each figure shows the predicted change in fish consumption in 2015 in response to brochure intervention as reflected by the regression models. These predicted changes are depicted as a function of fish consumption in 2014. In both cases, the pattern was the same. Those individuals who ate more fish initially decreased their fish consumption to a greater degree in response to the intervention. For some levels of baseline fish consumption, the change in fish consumption was non-significant. Through our application of the Johnson-Neyman technique, these figures indicate the baseline consumption levels above and below which the effect of the intervention is significant.

Table VI. Terms (and standard errors) for OLS regressions estimating total, purchased, and sport-caught fish consumption in 2015 (n=1,041).

	Total Fish Consumption	Purchased Fish Consumption	Sport-caught Fish Consumption
Constant	2.521***	2.415***	0.114
	(0.675)	(0.575)	(0.172)
Meals2014[1] (total, purchased, or sport-caught)	0.847***	0.865***	0.775***
	(0.033)	(0.033)	(0.028)
Intervention	0.159	0.135	0.573**
	(0.814)	(0.699)	(0.207)
Intervention*Meals2014	-0.073	-0.083*	-0.210***
	(0.039)	(0.039)	(0.033)

[1]Number of meals consumed in 2014.
*p<0.05, **p<0.01, ***p<0.001

The brochure significantly decreased purchased fish consumption in anglers who ate 12 or more meals of purchased fish over the course of the summer (48% of anglers in the sample). The brochure significantly decreased sport-caught fish consumption in anglers who ate 4 meals of fish or more over the course of the summer (24% of the sample). In both cases, the decrease was larger for anglers who ate more fish initially. The brochure also, however, led to a slight *increase* in sport-caught fish consumption in anglers who ate very little sport-caught fish initially. Anglers who ate 1 sport-caught fish in the summer of 2014 increased their fish consumption by 0.4 fish and those who ate no sport-caught fish in 2014 increased their consumption by 0.6 fish.

Although the interaction term in these models between "Intervention" and "Meals2014" provides some indication of whether anglers who are at greater risk are more affected by the brochure intervention, it is an imperfect indication. Anglers who eat more fish may not be at risk if they choose the types of fish carefully. Consequently, we also tested whether the effects of the brochure differed for those anglers who exceeded the guidelines in 2014. To do this, we included a dichotomous term in the model for "advisory exceedance" and allowed for an interaction term between "advisory exceedance" and the brochure intervention ("intervention").

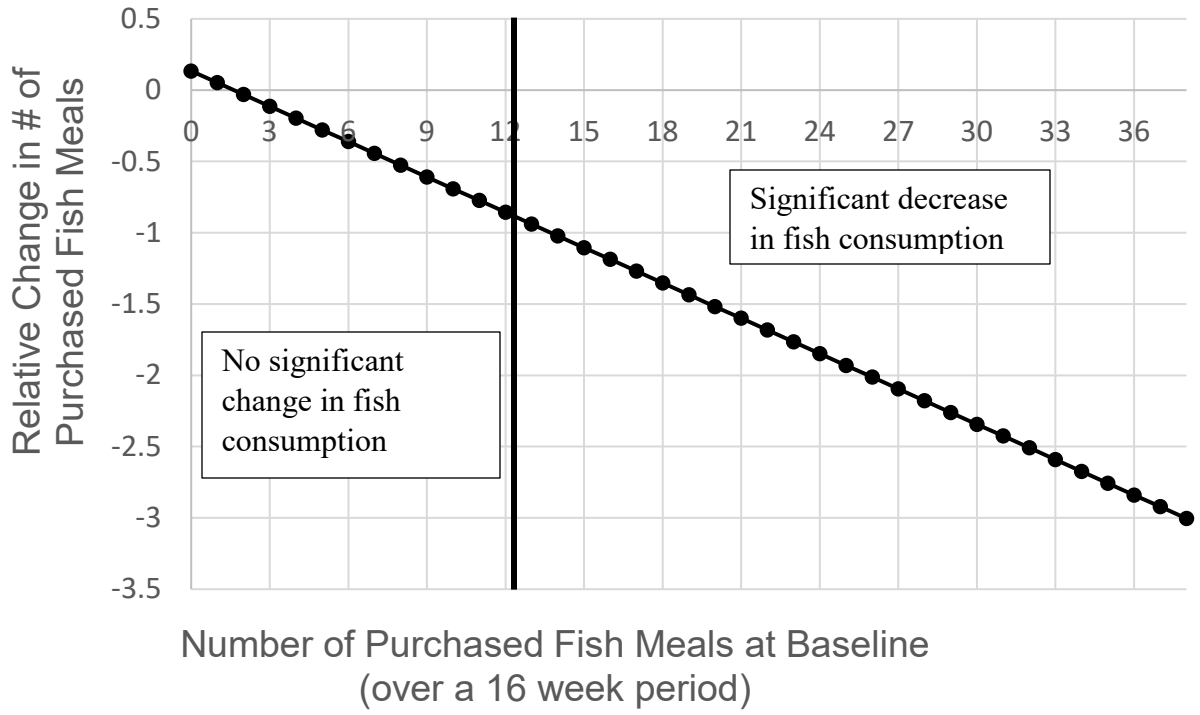

Figure 6. Predicted change in purchased fish consumption in 2015 for intervention compared to control group based on regression based on regression equation from Table VI. Vertical line indicates point at which decrease in fish consumption becomes significant.

The models for total and purchased fish consumption showed no evidence that anglers who exceeded the guidelines were more likely than those who did not to reduce their fish consumption in response to the brochure. The model for sport-caught fish consumption, however, contained a significant interaction term between "intervention" and "advisory exceedance" (when we assumed the most restrictive consumption recommendations for meals in which the species or length of fish caught was unknown) (Table VII). The significant interaction between the intervention and advisory exceedance and the lack of a significant main effect for the intervention indicates that the brochure only influenced sport-caught fish consumption among those anglers who exceeded the advisories in 2014. In those individuals, the brochure led to the consumption of nearly 2 fewer sport-caught fish meals over the course of the 4-month summer period in 2015. (The version of the brochure did not matter.).

Although the results above indicate that the brochure led to a reduction in fish consumption among urban anglers, they do not demonstrate the degree of reduction in risk. If anglers reduce their fish consumption by a given amount, they are more likely to reduce their risk if they reduce their consumption of high-contaminant rather than low-contaminant fish. Therefore, we assessed how the brochure affected both high-contaminant fish meals (those for which guidelines recommend fewer than one meal/week) and low-contaminant fish meals (those for which guidelines allow one meal/week or more). We re-estimated the models we had developed for total, purchased, and sport-caught fish consumption replacing the dependent variables (total, purchased, and sport-caught fish consumption in 2015) with both high-contaminant fish consumption in 2015 (total, purchased and sport-caught) and low-contaminant fish consumption

in 2015 (total, purchased and sport-caught) (Table VIII). The significant negative interaction terms in each model indicate that that the brochure reduced consumption of high-contaminant fish (total, purchased, and sport-caught) and low contaminant sport-caught fish for individuals who ate relatively large amounts of fish.

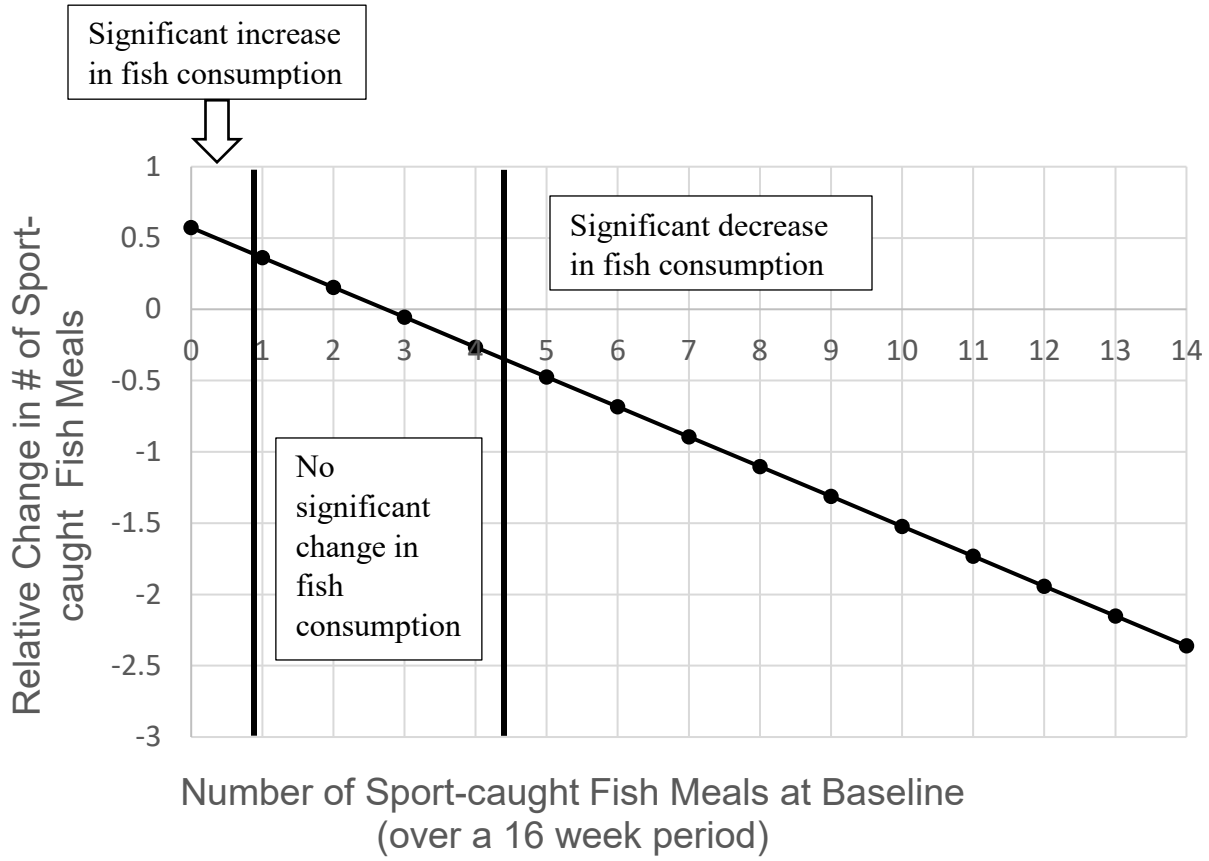

Figure 7. Predicted change in sport-caught fish consumption in 2015 for intervention compared to control group based on regression based on regression equation from Table VI. Vertical lines indicate points at which increase or decrease in fish consumption become significant.

The pattern of reduction in consumption was similar in all of these re-estimated models (Table IX). The reduction in fish consumption was larger for anglers who ate more fish initially. The top 13-28% of total, purchased, and sport-caught fish consumers significantly reduced their consumption of high-contaminant fish and low-contaminant sport-caught fish if they received the brochure. The brochure also affected fish consumption in anglers who ate little to no purchased fish and sport-caught fish initially. These anglers *increased* their consumption of high-contaminant purchased fish and high-contaminant sport-caught fish if they received the brochure.

Table VII. Terms (and standard errors) for OLS regression estimating sport-caught fish consumption in 2015 (n=1,041).

	Sport-caught Fish Consumption
Constant	0.418**
	(0.162)
Meals2014[1] (sport-caught)	0.635***
	(0.021)
Intervention	0.144
	(0.191)
AdvisoryExceedance (most restrictive assumptions[2])	1.121*
	(0.446)
Intervention*Advisory Exceedance	-1.964***
	(0.502)

[1]Number of meals consumed in 2014.
[2]When the species or length of fish caught was unknown, adherence to the guidelines was calculated in this case with the most restrictive consumption recommendations.
*p<0.05, **p<0.01, ***p<0.001

Table VIII. Terms (and standard errors) for OLS regressions estimating high-contaminant total, purchased, and sport-caught fish consumption and low-contaminant sport-caught fish consumption in 2015 (n=1,041).

	High-Contaminant Total Fish Consumption	High-Contaminant Purchased Fish Consumption	High-Contaminant Sport-caught Fish Consumption	Low-Contaminant Sport-caught Fish Consumption
Constant	-0.134	-0.253	-0.210	0.215
	(0.323)	(0.144)	(0.139)	(0.121)
Meals2014[1] (total, purchased, or sport-caught)	0.112***	0.056***	0.428***	0.260***
	(0.016)	(0.008)	(0.022)	(0.019)
Intervention	0.631	0.378*	0.338*	0.196
	(0.389)	(0.175)	(0.168)	(0.146)
Intervention*Meals2014	-0.046*	-0.033***	-0.090***	-0.096***
	(0.018)	(0.010)	(0.027)	(0.023)

[1]Number of meals consumed in 2014.
*p<0.05, **p<0.01, ***p<0.001

Table IX. Brochure effects on consumption of high-contaminant total, purchased, and sport-caught fish and low-contaminant sport-caught fish based on OLS regression models (n=1,041).

	Initial Fish Consumption over 1st 16-week Period (Total, Purchased, or Sport-caught)	Percentile	Change in High- or Low-Contaminant Fish Consumption over 2nd 16-week Period
High-Contaminant Total Fish Consumption	25[1]	78	-0.5
	34	90	-0.9
High-Contaminant Purchased Fish Consumption	0	4	+0.4
	2[2]	8	+0.3
	19[1]	72	-0.2
	30	90	-0.6
High-Contaminant Sport-caught Fish Consumption	0[2]	40	+0.1
	8[1]	87	-0.4
Low-Contaminant Sport-caught Fish Consumption	5[1]	76	-0.3
	9	90	-0.7

[1]Initial level of consumption above which decrease in high- or low-contaminant fish consumption is significant.
[2]Initial level of consumption below which increase in high- or low-contaminant fish consumption is significant.

4. Discussion

We showed, through a randomized experiment, that carefully designed fish consumption guidelines brochures can have an effect on fish consumption by urban anglers. We are not aware of any other studies showing such effects experimentally. Most previous work on fish consumption guidelines has used indirect evidence to assess their effects, and, while important, this prior work has not conclusively demonstrated that these guidelines can influence behavior. Roosen et al. [(28)] and Verger et al. [(29)] used an experimental approach to establish the effects of advisories, but their fish consumption guidance was communicated during an in-person visit, which might be expected to have a greater impact on fish consumption behavior. Brochures are able to reach people more cheaply than in-person interventions.

We found mixed indications as to whether the brochures influenced fish consumption behavior in urban anglers as intended. We did not find evidence that the brochures caused people who were exceeding guidelines to change their behavior so that they no longer exceeded guidelines. Although that would have been the preferred effect, it is possible that a person could reduce their consumption of high-contaminant fish (and, therefore, their exposure to contaminants), but not reduce it enough to achieve compliance with the guidelines.

Consequently, we also tested whether the intervention reduced fish consumption. It did, but only for people who ate comparatively large amounts of fish (who are at elevated risk for advisory exceedance) and people who exceeded the advisories. Receiving the brochure led those eating 30 meals of purchased fish over the summer of 2014 (90^{th} percentile of fish eaters) to eat 2.3 fewer purchased fish meals in 2015. The brochure led those eating 9 meals of sport-caught fish over the summer of 2014 (90^{th} percentile) to eat 1.3 fewer sport-caught fish meals in 2015. In addition, those anglers who exceeded the guidelines in 2014 reduced their consumption of sport-caught fish by nearly 2 sport-caught fish over the summer of 2015 if they received the brochure compared to the control group. Thus, the brochure affected urban anglers who were at highest risk as reflected by their consumption of large amounts of fish.

A reduction in fish consumption, in and of itself, is not the desired outcome. The key outcome is a reduction in the consumption of contaminants, which could be most easily achieved by reducing the consumption of heavily contaminated fish or switching from eating highly contaminated fish to eating less contaminated fish [26]. The intervention did lead to a reduction in the consumption of high-contaminant fish (total, purchased, and sport-caught) for heavy fish consumers, but it also led to a reduction in low-contaminant sport-caught fish. It did not lead to a reduction in low-contaminant purchased fish. These reductions in fish consumption were all relatively small, but even small reductions in high-contaminant fish consumption can be important in reducing exposure to contaminants. Roosen et al.'s [28] experimental study of the effects of a fish consumption intervention also reported a decrease in fish consumption, but they did not find a decrease in consumption of the most contaminated fish. Future research that pairs data on fish consumption with estimates of the contaminants in different types of fish could provide a more detailed indicator of how interventions affect the contaminant burdens in urban anglers.

In addition to leading to decreases in fish consumption for anglers who ate relatively large amounts of fish, the brochure also led to *increases* in fish consumption for anglers who ate very little of certain types of fish (0-2 meals over a 16-week period). We observed these increases for sport-caught fish consumption, high-contaminant sport-caught fish consumption, and high-contaminant purchased fish consumption. These increases in fish consumption are also beneficial as long as they do not result in anglers exceeding consumption guidelines. Fish consumption, even the consumption of high-contaminant fish (which we defined as fish anglers were advised to eat less than once/week), has many health benefits. Consequently, anglers who were eating almost no fish initially could benefit from increased consumption.

Our study had several limitations that could affect the degree to which the results that we obtained would be observed in other contexts. First, outreach programs targeting urban anglers often focus on subpopulations that are considered at particular risk (low-income and racial and

ethnic minorities); racial minorities in particular made up only a small portion of our sample. We attempted to recruit a representative sample of urban anglers, but excluded 8% of the individuals we contacted because they did not have email or internet access. Although 8% is a small percentage, it may have biased our sample because lower income householders are less likely than higher income households to have internet access [45]. Our final sample was 93-97% white. Based on other studies using similar methodology [46-47], our study may have underrepresented racial minorities from the geographic areas we sampled, but we cannot assess the degree to which it underrepresents these groups because no population-level data on the racial composition of licensed anglers at our study sites exists.

In addition, our method of distributing the fish guidelines brochures is not an approach that outreach programs typically use; we sent the brochures to individuals who had already agreed to participate in our study and who were communicating with us at least biweekly through the fish consumption diaries. The effects of brochures distributed through other means might be either lower (e.g., if anglers were sent the brochure unsolicited) or greater (e.g., if anglers were given the brochure by a trusted source like a health professional).

It is clear, however, that fish consumption guidelines brochures can have effects on target audiences. Future research that could improve our understanding of the effects of such interventions might assess the effects of brochure interventions on contaminant ingestion or accumulation in the body, explore the effectiveness of different delivery methods for brochures, or explore the effectiveness and cost-effectiveness of different types of interventions.

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APPENDIX A: USE OF DIARIES TO RECORD FISH CONSUMPTION

Participants could record information as often as they wanted within each two-week period. Did most participants record all of the meals they ate at one time or did they record them more often, suggesting that they reported them at the time when they were eaten? During some two-week periods, participants ate only one meal (28% of periods for WCBA, 35% of periods for urban anglers); information from these periods was not used in answering the question of interest in this Appendix. Among the periods when more than one meal was eaten, in 48% of these periods for WCBA and 49% of these periods for urban anglers all meals were recorded at one time. This suggests that half of the time when two or more meals are eaten in a two-week period, participants record the meals in their diary at one point in time and likely not at the time when they were eaten. These findings do not provide insight into ideal diary period length.

APPENDIX B: RESULTS FROM NORTHERN MINNESOTA WOMEN OF CHILDBEARING AGE SPECIAL SAMPLE

The Minnesota Department of Health (MN DOH) conducted a related study in northern Minnesota. The MN DOH recruited twenty-six WCBA for that study, not necessarily anglers, to participate in the diary as a separate sample. Complete results from that sample are listed in all tables as "MN (special sample)" in the Year 1 report to the Consortium (Connelly et al. 2015). We present a summary of the most relevant findings below.

Sixteen of the 26 Northern Minnesota WCBA recruited provided information throughout the Year 1 study period. (One WCBA provided partial information and is not included in the following results.) We compare WCBA in the special sample (n=16) to WCBA from Minnesota living in counties bordering Lake Superior who participated in the larger diary study (n=69) in the tables below.

Table B-1. Select socio-demographic characteristics by study strata.

	Percent with children aged 15 or younger in household	Percent white	Mean age
Minnesota	36.4	98.5	33.0
MN (special sample)	32.2	100.0	32.6

Table B-2. Education level by study strata.

	Percent		
	H.S. diploma or less	Some college	College degree or more
Minnesota	4.5	39.4	56.1
MN (special sample)	35.7	35.7	28.6

Table B-3. Average number of meals consumed during study period (total, purchased, and sport-caught) and the proportion of meals that were sport-caught by study strata.

	Average number of meals consumed during study period			% Sport-caught
	Total	Purchased	Sport-caught	
Minnesota	14.6	10.2	4.4	32.5
MN (special sample)	12.1	7.1	4.9	33.7

Table B-4. Most popular purchased fish meals by study strata.

	Percent of purchased fish meals					
	Shellfish[1]	Salmon	Canned light tuna	Canned white tuna	Cod	Haddock
Minnesota	25.7	16.5	18.3	11.1	4.0	1.0
MN (special sample)	8.8	9.6	20.2	13.2	12.3	3.5

[1] Shellfish included as examples shrimp, crabs, scallops, and clams.

Table B-5. Percent exceeding the fish consumption guidelines, as defined for our study and the primary species associated with exceeding the guidelines by study strata.

	Percent exceeding guidelines[1]	Primary species associated with exceeding the guidelines
Minnesota	33-41	Canned "white" tuna, walleye.
MN (special sample)	19-25	Canned "white" tuna.

[1] Estimates are presented as ranges because some advice is based on the length of the fish caught; if consumers did not know the length of the fish they ate then we estimated their consumption assuming both the most and least conservative consumption recommendations

Twelve Northern Minnesota WCBA participated in the second year of the project. They did not receive a version of the experimental brochure that contained the narrative. Therefore, no analysis could be done to see if these women consumed more fish in Year 2, similar to the findings of the larger group that received a narrative version of the brochure.

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APPENDIX C: DO INDIVIDUALS EAT A VARIETY OF PURCHASED FISH?

We found that WCBA, on average, ate 4.1 different purchased species over a 16-week period, with a range of 1 to 13 species. Thirteen percent ate only one species over a 16-week period.

We found that urban anglers, on average, ate 4.7 different purchased species over a 16-week period, with a range of 1 to 16 species. Ten percent ate only one species over 16-week period.

Note: The surveys did not distinguish between various forms of shellfish (shrimp vs. scallops, etc.). Therefore, the analyses above treat all shellfish as one species, and thus may underestimate the variety of seafood species consumed.

Table C-1. Number of different purchased fish species eaten during a 16-week period by WCBA and urban anglers.

	Percent	
Number of different purchased fish species eaten	WCBA	Urban anglers
1	12.8	10.4
2	14.5	11.4
3	17.4	14.6
4	17.1	15.3
5	13.4	15.0
6	9.7	11.2
7	6.8	8.8
8	3.9	5.4
9	2.1	4.1
10	1.3	1.6
11	0.8	0.7
12	0.1	0.8
13	0.1	0.3
14	0.0	0.3
15	0.0	0.0
16	0.0	0.1

APPENDIX D: WOMEN OF CHILDBEARING AGE: PROFILE OF TOP 10% OF FISH CONSUMERS AND OF WOMEN WHO EXCEED FISH CONSUMPTION GUIDELINES

Table D-1. Socio-demographic characteristics of WCBA who were among the top 10% of fish consumers or were among those who exceeded the guidelines in Year 1.

	Percent	
Socio-demographic characteristics	**Top 10% of fish consumers**	**Those exceeding liberal guidelines**
Age		
18-29	21.1	22.6
30-39	34.5	37.0
40-49	44.4	40.4
Race		
White	89.1	93.5
Non-white	10.9	6.5
Education level		
H.S. or less	8.8	7.4
Some college	39.0	45.5
College degree	39.0	33.5
Graduate or professional degree	13.2	13.6
Household income		
< $25,000	9.1	14.4
$25,000-$49,999	18.2	17.9
$50,000-$74,999	15.9	19.7
$75,000-$99,999	23.9	22.2
$100,000-$149,999	19.3	16.6
$150,000 +	13.6	9.2
Might get pregnant in next 5 years	33.5	32.6
Children 15 or younger in the household	38.7	45.0

Table D-2. Percent of purchased and locally-caught meals eaten by WCBA in Year 1, by those who ate the most meals (top 10%) versus others.

	Percent of meals	
Fish meals eaten in Year 1	**Top 10% of fish consumers**	**Other 90% of fish consumers**
Locally-caught fish	15.8	18.7
Purchased fish	84.2	81.3
Shellfish	25.9	24.7
Salmon	14.7	9.9
Canned “light” tuna	5.8	8.6
Cod	4.8	6.9
Canned “white” tuna	5.0	6.6
Tilapia	5.7	4.1
Fish sticks/fast food sandwiches	2.2	3.5
Haddock	1.9	2.7
Tuna (not canned)	2.8	2.0
Catfish (farm-raised)	2.3	0.8
Perch (purchased)	0.6	0.9
Other purchased fish	12.5	10.6

APPENDIX E: WOMEN OF CHILDBEARING AGE: RESULTS FROM TWO SURVEYS ON AWARENESS OF GUIDELINES, BELIEFS ABOUT FISH CONSUMPTION, AND SOCIO-DEMOGRAPHIC CHARACTERISTICS BY STATE

Note: In some cases results for neighboring states were combined due to small sample sizes in certain states. The initial sample design was not intended to provide state-specific results.

Table E-1. Population and sample sizes for WCBA diary study, overall and by state groupings.

Sample Sizes	Overall	NY	OH/PA	IL/IN	MI	WI/MN
WCBA angler population	125,040	18,154	16,954	13,813	40,514	35,605
Recruited	2,014	360	233	230	608	583
Included in Year 1 analysis	1,395	240	165	155	424	411
Included in experiment analysis	1,173	205	137	123	348	360

Table E-2. Socio-demographic characteristics for WCBA diary participants, overall and by state groupings.

	Percent					
Socio-demographic characteristics	**Overall**	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Age						
18-29	27.7	33.8	33.9	36.1	26.4	20.0
30-39	33.2	34.1	23.0	26.5	36.1	36.3
40-49	39.1	32.1	43.1	37.4	37.5	43.7
Race						
White	94.6	94.6	94.8	87.3	96.3	95.4
Non-white	5.4	5.4	5.2	12.7	3.7	4.6
Hispanic origin						
Yes	2.6	1.4	3.9	10.9	1.5	1.0
No	97.4	98.6	96.1	89.1	98.5	99.0
Education Level						
H.S or less	8.9	11.0	11.7	8.5	7.8	7.8
Some College	39.6	36.2	41.5	31.2	48.2	38.1
College degree	36.5	32.6	31.9	39.7	34.2	41.7
Graduate or professional degree	15.0	20.2	14.9	20.6	12.8	12.4
Household income						
< $25,000	10.9	12.5	9.2	12.1	15.8	5.5
$25,000-$49,999	19.1	21.7	19.3	15.4	17.3	20.5
$50,000-$74,999	22.4	18.4	28.4	18.7	22.2	23.8
$75,000-$99,999	22.9	27.0	19.3	23.0	17.7	27.1
$100,000-$149,999	17.4	17.8	16.5	16.5	19.5	15.8
$150,000 +	7.3	2.6	7.3	14.3	7.5	7.3
Pregnant or breastfeeding during Year 1 study	5.8	5.8	2.7	5.5	3.7	9.2
Pregnant or breastfeeding between Year 1 and Year 2	5.9	7.1	3.6	2.2	5.1	8.1
Pregnant or breastfeeding during Year 2 study	5.9	6.5	3.6	1.1	6.3	7.7
Might get pregnant in next 5 years	33.8	40.0	42.3	41.8	30.1	29.1
Children 15 or younger in household	51.4	52.0	49.0	42.3	52.6	54.0

Table E-3. Average fish consumption (# of meals in 16-week study period) for WCBA diary participants, overall and by state groupings.

	Mean					
Fish Consumption	**Overall**	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
# of meals	14.7	14.7	15.6	16.6	14.0	14.3
# of purchased meals	12.3	13.0	13.7	15.4	10.9	11.5
# of locally-caught meals	2.4	1.7	1.9	1.2	3.1	2.8

Table E-4. Percent of meals of various species and portion sizes eaten in Year 1 by WCBA, overall and by state groupings.

	Percent of meals					
Purchased fish meals eaten in Year 1	**Overall**	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Shellfish	30.4	35.0	34.4	29.7	28.1	27.9
Salmon	13.6	8.1	16.6	15.6	14.4	12.9
Canned “light” tuna	9.7	8.1	10.9	9.5	10.2	9.5
Cod	7.8	4.5	5.4	5.1	7.2	13.3
Canned “white” tuna	7.6	9.4	5.9	9.0	7.3	7.2
Tilapia	5.5	6.2	4.8	8.0	5.2	4.5
Fish sticks/fast food sandwiches	3.9	3.5	4.5	3.6	4.2	3.5
Haddock	3.1	11.7	0.7	0.6	0.5	3.5
Tuna (not canned)	2.7	3.1	2.2	3.1	3.0	2.3
Catfish (farm raised)	1.4	1.0	1.3	2.3	1.7	1.0
Perch (purchased)	1.0	0.0	0.4	0.2	1.4	1.7
Other	13.3	9.4	12.9	13.3	16.8	12.7
Portion size of purchased fish						
< 8oz. uncooked	50.7	48.5	50.1	52.9	50.2	52.1
8oz. uncooked (6oz. cooked)	38.0	37.6	38.4	37.3	38.2	38.1
> 8oz. uncooked	11.3	13.9	11.5	9.8	11.6	9.8
Portion size of locally-caught fish						
< 8oz. uncooked	31.4	37.6	26.1	34.9	32.1	29.2
8oz. uncooked (6oz. cooked)	44.9	49.1	40.7	39.7	44.6	45.9
>8oz. uncooked	23.7	13.3	33.2	25.4	23.3	24.9

Table E-5. Awareness of fish consumption guidelines by WCBA, overall and by state groupings.

	Percent					
	Overall	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Heard about govt. agencies providing guidelines	65.5	63.5	62.1	57.9	67.4	68.9
Aware of guidelines for locally-caught fish						
Not at all	46.4	48.4	53.9	55.8	44.8	40.6
Generally	45.7	44.3	37.5	37.1	46.6	52.0
Aware of specifics	7.9	7.3	8.6	7.1	8.6	7.4
Aware of guidelines for purchased fish						
Not at all	64.4	69.1	64.1	57.9	62.5	66.2
Generally	33.2	26.8	34.6	37.1	35.5	32.5
Aware of specifics	2.4	4.1	1.3	5.0	2.0	1.3

Table E-6. Views on guidelines and beliefs about following the guidelines by WCBA, overall and by state groupings.

	Percent					
	Overall	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Guidelines provide enough information to decide whether or not to eat locally-caught fish						
Agree	57.1	65.3	37.4	50.6	61.6	57.3
Neutral	18.9	17.4	26.5	19.2	19.4	16.7
Disagree	13.7	10.7	26.5	15.1	11.4	12.6
Don't Know	10.3	6.6	9.6	15.1	7.6	13.4
Guidelines provide enough information to decide whether or not to eat purchased fish						
Agree	36.4	36.9	38.6	49.3	37.1	30.9
Neutral	26.0	27.0	26.5	19.2	25.3	28.0
Disagree	23.3	23.0	22.9	19.2	22.8	25.2
Don't know	14.3	13.1	12.0	12.3	14.8	15.9
I try to follow the guidelines when deciding types of fish to eat						
Agree	57.0	59.1	47.5	54.9	61.9	55.1
Neutral	26.2	29.6	22.0	28.2	24.8	26.7
Disagree	16.8	11.3	30.5	16.9	13.3	18.2
I try to follow the guidelines when deciding how much fish to eat						
Agree	52.4	52.6	39.8	53.5	55.2	53.6
Neutral	27.5	31.9	22.9	26.8	29.6	25.3
Disagree	20.1	15.1	37.3	19.7	15.2	21.1

Table E-7. Sources of guideline information and their perceived usefulness by WCBA, overall and by state groupings.

	Percent					
Information sources seen	**Overall**	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Fishing regulations guide	31.1	30.9	23.9	21.8	35.5	32.9
Friends or family	19.8	18.8	21.9	20.4	18.9	20.3
Websites	19.8	23.3	18.7	21.8	19.9	17.5
Health information brochures	15.8	11.2	16.8	17.6	16.1	17.0
Newspaper articles	14.7	12.1	9.0	14.1	14.4	19.0
TV or radio	14.0	14.3	14.2	15.5	11.4	15.9
Posted warnings at fishing locations	13.2	7.2	9.7	12.0	13.6	18.0
Healthcare providers	10.7	5.8	9.0	8.5	13.2	12.3
Sportsman's shows or outdoor expos	3.8	3.6	2.6	2.8	4.0	4.6
iPhone/smartphone apps	2.9	3.6	2.6	2.1	2.2	3.6
Source rated as very useful						
Fishing regulations guide	45.4	45.2	47.1	41.4	48.5	42.5
Friends or family	26.5	21.1	--	--	30.6	27.8
Websites	34.9	36.2	--	--	38.4	27.7
Health information brochures	27.8	--	--	--	33.3	20.7
Newspaper articles	19.5	--	--	--	21.1	15.5
TV or radio	21.5	--	--	--	23.9	21.4
Posted warnings at fishing locations	55.4	--	--	--	48.0	66.2
Healthcare providers	36.2	--	--	--	44.0	36.6
Sportsman's shows or outdoor expos	30.8	--	--	--	--	--
iPhone/smartphone apps	17.6	--	--	--	--	--

--sample size too small

Table E-8. Belief statements included in Year1 survey for WCBA, overall and by state groupings.

Belief statements-Year 1	Percent					
	Overall	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Any health problems from eating fish contaminated with chemicals are mainly short-term						
Agree	8.2	5.4	10.3	7.0	10.2	7.2
Neutral	16.3	19.8	14.8	12.0	15.7	17.0
Disagree	55.6	50.9	56.2	57.1	55.9	57.3
Don't know	19.9	23.9	18.7	23.9	18.2	18.5
Benefits outweigh risks if women eat fish low in mercury and other contaminants						
Agree	46.4	39.0	45.9	52.1	49.7	45.5
Neutral	19.4	27.8	20.6	14.1	16.9	18.5
Disagree	21.6	20.6	18.7	19.7	23.4	22.1
Don't know	12.6	12.6	14.8	14.1	10.0	13.9
Most of the women I know ate fish when they were pregnant						
Agree	38.2	35.1	30.3	37.3	37.9	43.8
Neutral	15.9	18.5	18.7	12.0	16.5	14.1
Disagree	25.1	29.3	27.1	27.5	23.7	22.6
Don't know	20.8	17.1	23.9	23.2	21.9	19.5
Women who follow the guidelines can get a lot of the health benefits of eating fish with very little risk to themselves or their children						
Agree	68.0	64.8	69.6	69.0	68.5	68.3
Neutral	16.9	22.1	14.2	16.9	16.5	15.5
Disagree	4.1	4.1	3.9	4.2	4.0	4.1
Don't know	11.0	9.0	12.3	9.9	11.0	12.1
Children's health can be harmed more than adults' health by chemical contaminants in fish						
Agree	57.8	53.3	58.7	63.4	58.7	57.3
Neutral	13.8	18.1	14.2	9.9	13.7	12.6
Disagree	8.8	10.0	11.0	6.3	7.5	9.5
Don't know	19.6	18.6	16.1	20.4	20.1	20.6

Table E-8. (cont.)

Belief statements-Year 1	Percent					
	Overall	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
An unborn baby's health can be harmed more than it's mother's health by chemical contaminants in the fish that the mother eats						
Agree	65.5	64.7	63.2	67.7	66.0	65.4
Neutral	11.6	15.4	11.6	7.0	12.2	10.6
Disagree	4.7	4.1	6.5	4.2	4.0	5.4
Don't know	18.2	15.8	18.7	21.1	17.8	18.6

Table E-9. WCBA's perception of changes in fish consumption between Year 1 and Year 2, overall and by state groupings.

	Percent					
	Overall	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Changed amount or types of fish consumed between Year 1 and Year 2	34.1	35.6	40.0	38.5	33.0	30.6
Ate more purchased fish	13.3	13.5	14.3	16.1	11.8	13.4
Ate less purchased fish	14.0	18.4	20.5	18.3	10.7	10.7
Changed type of purchased fish	6.4	6.7	9.8	9.7	4.6	5.7
Ate more locally-caught fish	6.9	4.9	1.8	3.2	9.3	8.7
Ate less locally-caught fish	14.5	13.5	16.1	14.0	15.0	14.1
Changed type of locally-caught fish	1.8	2.5	1.8	2.2	2.1	1.0

Table E-10. For WCBA receiving an experimental brochure, recollection of brochure and views on impact and content, overall and by state groupings.

	Percent					
For those in experimental group	**Overall**	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Recall seeing the brochure						
No	24.2	22.3	41.3	22.0	24.6	19.1
Yes, in the mail	63.2	67.9	49.3	64.4	66.7	62.3
Yes, online	16.6	11.6	13.3	22.0	12.6	22.6
For those who recall seeing the brochure						
Agreement with:						
The brochure was easy to read and understand	90.7	93.0	93.2	93.5	89.9	88.8
The brochure was NOT relevant to me or my life circumstances	10.1	7.1	6.8	8.7	9.4	13.7
The brochure provided enough information to decide how often to eat certain purchased fish	72.1	65.5	75.0	76.1	69.6	75.8
The brochure provided enough information to decide how often to eat locally-caught fish	74.4	74.7	70.5	58.7	78.3	76.4
Reading the brochure made me feel more more comfortable about eating fish	49.2	36.0	61.4	52.2	47.4	53.4
Reading the brochure made me want to eat less fish	13.9	14.9	22.7	6.5	18.8	8.7
Reading the brochure made me want to eat more fish	14.8	11.5	9.1	28.9	12.4	16.3
Reading the brochure made me want to change the types of fish I ate	33.1	34.5	38.6	42.2	30.4	30.4
Reading the brochure made me worry more about chemicals in fish	50.9	52.9	50.0	53.3	58.0	43.5

Table E-11. Belief statements included in Year 2 survey for WCBA, overall and by state groupings.

Belief statements- Year 2	Percent					
	Overall	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
Any health problems from eating fish contaminated with chemicals are mainly short-term						
Agree	8.5	7.0	8.1	6.8	7.7	10.6
Neutral	20.1	18.8	23.0	16.9	19.7	21.1
Disagree	54.5	55.4	50.0	49.2	55.1	56.7
Don't Know	16.9	18.8	18.9	27.1	17.5	11.6
Eating fish that is low in mercury every week can help pregnant women have healthier babies						
Agree	35.8	36.5	30.6	43.8	29.5	40.7
Neutral	21.6	18.8	22.7	21.1	23.5	21.1
Disagree	27.3	31.3	26.7	12.3	31.2	26.1
Don't know	15.3	13.4	20.0	22.8	15.8	12.1
Some people will have health problems from eating fish contaminated with chemicals, while others won't						
Agree	51.5	48.2	46.7	51.7	57.8	49.3
Neutral	18.3	18.8	24.0	8.6	14.8	22.1
Disagree	17.9	20.5	16.0	19.0	14.8	19.6
Don't know	12.3	12.5	13.3	20.7	12.6	9.0
Benefits outweigh risks if you eat fish low in mercury and other contaminants						
Agree	60.1	57.2	60.0	56.9	57.9	64.8
Neutral	21.9	20.5	26.7	19.0	24.0	19.6
Disagree	10.7	12.5	8.0	10.3	9.9	11.6
Don't know	7.3	9.8	5.3	13.8	8.2	4.0
Children's health can be harmed more than adults' health by chemical contaminants in fish						
Agree	74.0	75.0	72.0	75.9	77.0	70.9
Neutral	12.0	13.3	9.3	10.3	8.7	15.6
Disagree	5.9	5.4	6.7	5.2	6.6	5.5
Don't know	8.1	6.3	12.0	8.6	7.7	8.0

Table E-11. (cont.)

	Percent					
Belief statements- Year 2	**Overall**	**NY**	**OH/PA**	**IL/IN**	**MI**	**WI/MN**
An unborn baby's health can be harmed more than it's mother's health by chemical contaminants in the fish that the mother eats						
Agree	74.9	73.0	76.0	75.9	77.6	72.8
Neutral	11.0	11.7	9.3	10.3	10.4	12.1
Disagree	4.0	4.5	2.7	3.5	3.3	5.0
Don't know	10.1	10.8	12.0	10.3	8.7	10.1
Women who follow the fish eating guidelines can minimize their health risks						
Agree	87.8	91.0	88.0	87.9	90.1	83.9
Neutral	7.8	4.5	9.3	6.9	6.6	10.6
Disagree	1.0	0.9	0.0	0.0	0.0	2.5
Don't Know	3.4	3.6	2.7	5.2	3.3	3.0

APPENDIX F: SPECIES OF FISH CONTRIBUTING THE MOST TO WOMEN OF CHILDBEARING AGE EXCEEDING FISH CONSUMPTION GUIDELINES

We estimated the degree to which advisory exceedance was affected by the consumption of particular species of fish, consumption of fish from particular water bodies, and the consumption of too much lower mercury purchased fish[19]. To estimate the contribution of particular species of fish to advisory exceedance, we eliminated the consumption data from each species of fish in turn, recalculated advisory exceedance, and calculated the percentage reduction in advisory exceedance. For example, to get an estimate of how much walleye consumption contributed to advisory exceedance, we calculated advisory exceedance without any data on walleye consumption. We used a similar approach to estimate the degree to which consumption of fish from particular local water bodies contributed to advisory exceedance. For some individuals, advisory exceedance was not caused by the consumption of particular contaminated fish, but by consumption of too much purchased fish with lower levels of mercury. To estimate the degree to which consumption of too much purchased fish contributed to advisory exceedance, we eliminated the consumption data for lower mercury purchased fish, recalculated advisory exceedance, and calculated the percentage reduction in advisory exceedance.

We selected just those individuals who exceeded the advisory guidelines based on conservative assumptions and calculated the relative contributions of different types of fish consumption to advisory exceedance (Table F-1). Walleye and swordfish, made a sizeable contribution to the exceedance of WCBA across several states. The consumption of too much lower mercury purchased fish made a significant contribution to advisory exceedance in several states. In New York, where WCBA are advised not to consume any fish from certain Great Lakes waters, consumption of fish from Lake Ontario, more so than the St. Lawrence River, contributed to advisory exceedance.

[19] We defined low-mercury purchased fish as fish classified in a state's guidelines as 2/week or 1/week (for MN, MI, WI, and IN). For states that followed federal guidelines for purchased fish (NY, PA, OH, IL), we defined purchased fish as all fish, except the do not eat species.

Table F-1. Percentage reduction in advisory exceedance from eliminating certain types of fish consumption from data set.

	NY	PA	OH	IN	IL	MI	WI	MN
Purchased fish								
Canned "white" tuna	0	0	0	0	0	10	23	21
Shark	6	0	17	0	0	2	10	0
Swordfish	16	25	22	0	14	4	8	7
Too much low-mercury purchased fish[1]	7	25	44	0	64	22	4	0
Sport-caught fish								
Chinook salmon	0	0	0	0	7	3	4	0
Coho salmon	0	0	0	0	14	2	3	0
Lake trout	0	0	0	0	0	4	0	0
Walleye	0	25	0	0	0	21	7	36
White perch	0	38	11	0	0	1	0	0
Fish from specific water bodies								
Lake Ontario	40	-	-	-	-	-	-	-
St. Lawrence River	16	-	-	-	-	-	-	-

[1]Purchased fish with recommended limits of one/week or two/weeks in MN, MI, WI, and IN; and all fish, except the do not eat species, for those following federal guidelines (NY, PA, OH, IL).

APPENDIX G: URBAN ANGLERS: RESULTS FROM TWO SURVEYS ON AWARENESS OF GUIDELINES, BELIEFS ABOUT FISH CONSUMPTION, AND SOCIO-DEMOGRAPHIC CHARACTERISTICS BY STATE

Table G-1. Population and sample sizes for urban angler diary study, by urban area.

Sample Sizes	**Kalamazoo, MI**	**Erie, PA**	**Rochester, NY**
Urban angler population	16,016	11,804	36,963
Recruited	610	705	784
Included in Year 1 analysis	414	449	500
Included in experiment analysis	327	364	390

Table G-2. Socio-demographic characteristics for urban angler diary participants, by urban area.

Socio-demographic characteristics	Percent		
	Kalamazoo, MI	**Erie, PA**	**Rochester, NY**
Gender			
Male	82.3	83.7	81.6
Female	17.7	16.3	18.4
Age			
18-34	18.2	24.3	19.8
35-49	26.6	29.2	26.8
50-59	19.9	29.6	23.4
60+	35.3	16.9	30.0
Race			
White	95.3	95.0	91.5
Black	1.3	1.4	5.0
Other	3.4	3.6	3.5
Hispanic Origin			
Yes	0.8	1.0	0.8
No	99.2	99.0	99.2
Education Level			
H.S. or less	7.8	17.2	11.5
Some college	30.0	36.2	35.8
College degree	34.0	28.0	29.4
Graduate or professional degree	28.2	18.6	23.3
Household Income			
< $25,000	5.7	5.1	3.5
$25,000-$49,999	15.9	20.1	15.8
$50,000-$74,999	23.2	21.7	21.8
$75,000-$99,999	17.1	25.1	23.2
$100,000-$149,999	26.3	19.3	26.2
$150,000+	11.8	8.7	9.5
Children 15 or younger in household			
Yes	34.4	39.0	31.8
No	65.6	61.0	68.2

Table G-3. Average fish consumption (# of meals in 16 week study period) for urban angler diary participants, by urban area.

	Mean		
Fish consumption	**Kalamazoo, MI**	**Erie, PA**	**Rochester, NY**
# of meals	18.4	15.7	19.5
# of purchased meals	14.3	11.2	17.2
# of locally-caught meals	4.1	4.5	2.3

Table G-4. Percent of meals of various species and portion sizes eaten in Year 1 by urban anglers, by urban area.

	Percent		
Purchased fish meals eaten in Year 1	**Kalamazoo, MI**	**Erie, PA**	**Rochester, NY**
Shellfish	23.3	29.3	30.5
Salmon	18.9	13.3	13.7
Canned “light” tuna	6.8	8.8	7.2
Cod	10.5	7.4	3.5
Canned “white” tuna	6.4	8.4	10.2
Tilapia	4.7	4.5	4.9
Haddock	1.4	4.2	13.3
Other	28.2	24.0	16.7
Portion size of purchased fish			
< 8oz. uncooked	45.6	44.2	44.2
8oz. uncooked (6oz. cooked)	40.5	40.9	40.8
> 8oz. uncooked	13.9	14.9	15.0
Portion size of locally-caught fish			
< 8oz. uncooked	23.8	20.1	24.8
8oz. uncooked (6oz. cooked)	44.5	37.5	41.3
> 8oz. uncooked	31.7	42.4	33.9

Table G-5. Awareness of fish consumption guidelines by urban anglers, by urban area.

	Percent		
	Kalamazoo, MI	**Erie, PA**	**Rochester, NY**
Heard about govt. agencies providing guidelines	81.3	78.2	77.9
Aware of guidelines for locally-caught fish			
Not at all	23.5	26.9	26.9
Generally	56.9	53.1	57.9
Aware of specifics	19.6	20.0	15.2
Aware of guidelines for purchased fish			
Not at all	54.5	56.5	59.8
Generally	40.7	38.2	36.2
Aware of specifics	4.8	5.3	4.0

Table G-6. Views on guidelines and beliefs about following the guidelines by urban anglers, by urban area.

	Percent		
	Kalamazoo, MI	**Erie, PA**	**Rochester, NY**
Guidelines provide enough information to decide whether or not to eat locally-caught fish			
Agree	68.5	70.7	68.5
Neutral	19.6	16.1	14.9
Disagree	7.6	10.3	8.3
Don't know	4.3	2.9	8.3
Guidelines provide enough information to decide whether or not to eat purchased fish			
Agree	35.2	35.0	33.6
Neutral	26.2	27.7	23.9
Disagree	28.6	27.3	25.3
Don't know	10.0	10.0	17.2
I try to follow the guidelines when deciding the types of fish to eat			
Agree	64.7	54.5	63.0
Neutral	21.9	26.4	25.3
Disagree	13.4	19.1	11.7
I try to follow the guidelines when deciding how much fish to eat			
Agree	59.7	48.7	55.5
Neutral	20.8	28.6	29.5
Disagree	19.5	22.7	15.0

Table G-7. Sources of guideline information and their perceived usefulness by urban anglers, by urban area.

	Percent		
Information sources seen	**Kalamazoo, MI**	**Erie, PA**	**Rochester, NY**
Fishing regulations guide	51.9	51.4	49.4
Friends or family	21.4	18.0	26.3
Websites	23.3	21.8	22.5
Health information brochures	12.7	14.7	17.1
Newspaper articles	33.6	33.4	35.0
TV or radio	21.7	17.3	14.8
Posted warnings at fishing locations	25.6	13.7	10.0
Healthcare providers	6.2	5.2	5.8
Sportsman's shows or outdoor expos	11.1	7.8	7.3
iPhone/smartphone apps	1.6	3.3	2.9
Source rated as very useful			
Fishing regulations guide	47.0	48.8	56.8
Friends and family	24.0	13.9	18.6
Websites	42.2	37.3	43.8
Health information brochures	41.9	25.9	28.6
Newspaper articles	16.2	16.8	22.2
TV or radio	17.1	9.1	20.0
Posted warnings at fishing locations	52.8	29.6	52.3
Healthcare providers	--	--	--
Sportsman's shows or outdoor expos	24.3	27.6	26.7
iPhone/smartphone apps	--	--	--

--Sample size too small

Table G-8. Belief statements included in Year 1 survey for urban anglers, by urban area.

	Percent		
Belief statements-Year 1	**Kalamazoo, MI**	**Erie, PA**	**Rochester, NY**
Any health problems from eating fish contaminated with chemicals are mainly short term			
Agree	9.0	8.7	8.2
Neutral	12.4	18.5	13.1
Disagree	66.5	56.4	61.7
Don't know	12.1	16.4	17.0
People who follow the fish eating guidelines can minimize their health risks and maximize their health benefits			
Agree	79.9	72.2	77.3
Neutral	10.8	18.0	14.1
Disagree	3.9	3.7	2.5
Don't know	5.4	6.1	6.1
Most of my family and friends try to follow the fish eating guidelines in their state			
Agree	43.3	32.2	40.5
Neutral	21.9	27.7	22.0
Disagree	16.8	25.1	17.1
Don't know	18.0	15.0	20.4
My family and friends think it is important that I follow the fish eating guidelines in my state			
Agree	37.7	31.7	37.1
Neutral	29.6	32.5	27.6
Disagree	17.1	22.6	16.0
Don't know	15.6	13.2	19.3
Children's health can be harmed more than adults' health by chemical contaminants in fish			
Agree	80.2	77.5	74.4
Neutral	9.1	8.7	7.2
Disagree	3.4	4.0	4.1
Don't know	7.3	9.8	14.3

Table G-8. (cont.)

Belief statements-Year 1	Percent		
	Kalamazoo, MI	**Erie, PA**	**Rochester, NY**
I don't think government agencies really know how much chemical contaminants are in fish			
Agree	43.6	44.2	40.6
Neutral	20.6	20.3	22.0
Disagree	31.7	27.3	31.2
Don't know	4.1	8.2	6.2

Table G-9. Urban angler perception of changes in fish consumption between Year 1 and Year 2, by urban area.

	Percent		
	Kalamazoo, MI	**Erie, PA**	**Rochester, NY**
Changed amount or types of fish consumed between Year 1 and Year 2	26.4	37.1	28.5
Ate more purchased fish	17.8	16.2	17.7
Ate less purchased fish	5.9	10.1	10.4
Changed type of purchased fish	3.0	6.5	6.6
Ate more locally-caught fish	6.3	5.8	2.5
Ate less locally-caught fish	16.7	19.8	6.9
Changed type of locally-caught fish	2.6	0.7	1.6

Table G-10. For urban anglers receiving an experimental brochure, recollection of brochure and views on impact and content, by urban area.

For those in experimental group	Percent		
	Kalamazoo, MI	Erie, PA	Rochester, NY
Recall seeing brochure			
No	26.5	37.1	28.3
Yes, in the mail	61.1	46.8	54.2
Yes, online	20.0	19.9	22.2
For those who recall seeing brochure			
Agreement with:			
The brochure was easy to read and understand	91.1	94.9	85.5
The brochure was NOT relevant to me or my life circumstances	14.8	12.8	17.2
The brochure provided enough information to decide how often to eat certain purchased fish	72.4	76.7	69.7
The brochure provided enough information to decide how often to eat certain locally-caught fish	74.1	82.9	79.5
Reading the brochure made me feel more comfortable about eating fish	45.2	38.8	49.3
Reading the brochure made me want to eat less fish	10.4	12.9	16.6
Reading the brochure made me want to eat more fish	13.3	6.0	13.8
Reading the brochure made me want to change the types of fish I ate	34.1	34.2	33.6
Reading the brochure made me worry more about chemicals in fish	44.4	45.7	49.3

Table G-11. Belief statements included in Year 2 survey for urban anglers, by urban area.

Belief statements-Year 2	Percent		
	Kalamazoo, MI	Erie, PA	Rochester, NY
Any health problems from eating fish contaminated with chemicals are mainly short-term			
Agree	9.3	8.6	7.9
Neutral	17.5	20.5	18.3
Disagree	58.7	57.6	59.6
Don't know	14.5	13.3	14.2
Fish contaminated with chemicals will taste bad			
Agree	8.2	15.1	11.7
Neutral	18.2	19.1	15.6
Disagree	60.2	57.2	58.7
Don't know	13.4	8.6	14.0
Some people will have health problems from eating fish contaminated with chemicals, while others won't			
Agree	56.8	52.2	50.0
Neutral	19.0	20.7	19.3
Disagree	13.4	17.0	20.6
Don't know	10.8	10.1	10.1
People who follow the fish eating guidelines can minimize their health risks			
Agree	86.2	86.0	85.9
Neutral	10.1	11.2	10.7
Disagree	1.1	1.4	0.6
Don't know	2.6	1.4	2.8
My family and friends think it is important that I follow the fish eating guidelines in my state			
Agree	51.3	40.9	49.5
Neutral	27.5	33.0	28.6
Disagree	8.6	14.1	9.2
Don't know	12.6	12.0	12.7

Table G-11. (cont.)

Belief statements-Year 2	Percent		
	Kalamazoo, MI	Erie, PA	Rochester, NY
Eating fish can lower your risk of heart disease			
Agree	85.5	78.4	78.8
Neutral	9.7	18.0	11.7
Disagree	0.7	0.7	1.6
Don't know	4.1	2.9	7.9
I don't think government agencies really know how much chemical contaminants are in fish			
Agree	49.4	50.4	46.5
Neutral	16.4	23.7	19.0
Disagree	28.6	23.0	28.5
Don't know	5.6	2.9	6.0

APPENDIX H: URBAN ANGLERS: THE AMOUNT OF FISH EATEN FOR EACH TYPE OF FISH IDENTIFIED IN THE GUIDELINES FOR EACH STUDY SITE

Table H-1. Meals of fish listed in the guidelines and the percent of people eating them, by water in Kalamazoo, MI.*

Fish listed in the guidelines and eaten from:	# of meals over 16-weeks	% of all meals from water	Of people who ate fish from this water, % who ate species
Austin Lake (n=24)			
Bullhead >10”	2	2.1	8.3
Bullhead unknown length	1	1.1	4.2
Carp <30”	3	3.2	8.3
Carp 30-34”	1	1.1	4.2
Carp >34”	1	1.1	4.2
Carp unknown length	1	1.1	4.2
Largemouth bass <18”	10	10.5	20.8
Largemouth bass >18”	4	4.2	12.5
Largemouth bass unknown length	3	3.2	12.5
Smallmouth bass <18”	4	4.2	16.7
Smallmouth bass >18”	4	4.2	8.3
Smallmouth bass unknown length	2	2.1	8.3
Eagle Lake (n=17)			
Largemouth bass <18”	5	23.8	23.5
Gourdneck Lake (n=17)			
Northern pike	3	5.9	17.6
Gull Lake (n=30)			
Largemouth bass	25	23.8	23.3
Northern pike	10	9.5	16.7
Smallmouth bass	3	2.9	3.3
Kalamazoo River (from Morrow Dam to Allegan Dam) (n=8)			
Catfish	1	3.8	12.5
Crappie	4	15.4	37.5
Sunfish	12	46.2	12.5
Walleye	3	11.5	25.0
Other species not listed	6	23.1	37.5

Table H-1 (cont.)

Fish listed in the guidelines and eaten from:	# of meals over 16-weeks	% of all meals from water	Of people who ate fish from this water, % who ate species
Kalamazoo River (between Ceresco Dam and Morrow Dam, including Morrow Lake) (n=6)			
Bluegill	20	87.0	83.3
Sunfish	3	13.0	16.7

*No one ate a species with a guideline from Barton Lake, Portage Creek (up or downstream of Monarch Mill Dam), or Ruppert Lake.

Table H-2. Meals of fish listed in the guidelines and the percent of people eating them, by water in Erie, PA.*

Fish listed in the guidelines and eaten from:	# of meals over 16 weeks	% of all meals from water	Of people who ate fish from this water, % who ate species
Lake Erie & tributaries Except Conneaut Creek (n=271)			
Carp <20”	2	0.2	0.7
Channel catfish	1	0.1	0.4
Coho salmon	2	0.2	0.7
Freshwater drum	5	0.4	0.7
Lake trout <30”	23	1.9	4.8
Lake trout unknown length	5	0.4	1.8
Lake whitefish	11	0.9	2.9
Smallmouth bass	20	1.6	2.9
Steelhead (rainbow trout)	37	3.0	10.0
Walleye	467	38.4	55.0
White bass	14	1.2	3.3
White perch	293	24.1	40.2
Presque Isle Bay (n=105)			
Bowfin	1	0.3	0.9
Carp	2	0.6	1.9
Coho salmon	2	0.6	0.9
Freshwater drum	1	0.3	0.9
Northern Pike	4	1.2	3.8
Smallmouth bass	24	7.0	12.4
Steelhead (rainbow trout)	9	2.6	6.7
White perch	67	19.5	40.0

*No one ate a species with a guideline from Conneaut Creek.

Table H-3. Meals of fish listed in the guidelines and the percent of people eating them from Lake Ontario near Rochester, NY.

Fish listed in the guidelines and eaten from:	# of meals over 16 weeks	% of all meals from water	Of people who ate fish from this water, % who ate species
Lake Ontario (n=108)			
Brown trout <20”	15	4.0	5.5
Brown Trout >20”	13	3.5	8.3
Brown Trout unknown length	2	0.5	1.8
Carp	1	0.3	0.9
Channel catfish	20	5.3	5.5
Chinook salmon	41	10.9	14.8
Coho salmon	20	5.3	11.1
Lake trout <25”	10	2.7	9.2
Lake trout >25”	18	4.8	10.2
Lake trout unknown length	13	3.5	6.5
Rainbow trout	26	6.9	14.8
White perch	40	10.6	23.1
White sucker	3	0.8	0.9

APPENDIX I: PROFILE OF URBAN ANGLERS WHO EXCEED FISH CONSUMPTION GUIDELINES

Table I-1. Socio-demographic characteristics of urban anglers who exceeded the liberal guidelines in Year 1.

Socio-demographic characteristics	Percent **Those exceeding liberal guidelines**
Gender	
Male	78.3
Female	21.7
Age	
18-34	16.8
35-49	23.5
50-59	23.9
60+	35.8
Race	
White	90.1
Black	4.1
Other	5.8
Education level	
H.S. or less	11.8
Some college	33.7
College degree	30.9
Graduate or professional degree	23.6
Household income	
< $25,000	4.3
$25,000-$49,999	18.1
$50,000-$74,999	21.7
$75,000-$99,999	16.7
$100,00-$149,999	24.7
$150,000+	14.5
Children 15 or younger in household	25.7